MPIC 5

MICROELECTRONIC RELAY
Designer's Manual

International Rectifier

International Rectifier

Microelectronic Relay

Designer's Manual

Solid State Relay
Applications and Product Data

Power IC Technology
for
Advanced Control Systems

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Microelectronic Relay

Designer's Manual

The ChipSwitch®
Microelectronic Power IC Relay

Introduction

This designer's manual features the ChipSwitch, a miniature solid state relay (SSR) which uses unique International Rectifier power ICs as the control device to switch AC power from 50 to 400 Hz. Two power ICs are connected in inverse parallel (analogous to anti-parallel SCRs). Each IC controls one polarity of the AC power line and also provides all of the supplementary functions performed by elaborate discrete component SSR circuits. Input isolation is provided by an electrically isolated light emitting diode (LED) whose infra-red radiation directly actuates the output power ICs.

The ChipSwitch can be applied wherever it is necessary to control AC power loads from logic level, isolated DC signals. It is an ideal interface allowing microprocessor outputs to control AC solenoids, electrical valves, lamps, heaters, small motors, power contactors and annunciators.

Traditional solid state advantages of long switching life, low input power, fast response, no bounce, EMI-free operation, miniaturization, and reliability are all major features of ChipSwitch relays.

Each ChipSwitch features controlled zero voltage turn-on. The excellent dv/dt ratings eliminate the need for bulky, leaky, failure-prone RC snubber networks, even on low power factor inductive loads. Safety standard qualification from UL, CSA, and VDE have been achieved or are pending. Great overall system economy can result from International Rectifier's combination of power IC technology, miniature packaging, assured safety standard approvals, and reliable, wear out free operation.

Three ChipSwitch package styles are available from International Rectifier. See page B-2 for the product line summary. AC line voltages from 20 to 280 VAC and current levels to 3.0 amperes can be controlled. In summary, designer's will find the ChipSwitch microelectronic power IC relay an ideal solid state control device for AC loads from milliamperes up to the range of several hundred watts.

Microelectronic Relay

Designer's Manual

The BOSFET® PVR
Microelectronic Power IC Relay

Introduction

The photovoltaic relay (PVR) devices featured in this designer's manual use unique International Rectifier power ICs, termed BOSFETs, as the solid state relay (SSR) output for switching a great variety of analog and digital signals.

The BOSFET power IC contains two power MOSFETs in inverse series connection for distortion-free control of bidirectional (AC) and DC signals. A fast turn-off circuit plus transient suppression circuitry are each integrated into the BOSFET. These PVRs also contain a unique, multicell photovoltaic generator developed by International Rectifier which controls the BOSFET. Input isolation is provided by an electrically isolated light emitting diode (LED) whose infra-red radiation energizes the photovoltaic generator.

The power MOSFET type of output allows International Rectifier PVRs to control analog signals from millivolts to hundreds of volts, from nanoamps to hundreds of milliamps, and from DC to hundreds of kilohertz. These PVRs are widely applied in instruments, multiplexers, data acquisition, automatic test equipment, telecommunications, and a wide variety of general purpose AC and DC signal switching functions.

The solid state characteristics of PVRs allow them to greatly exceed the performance of the best reed and general purpose signal level electromechanical relays (EMRs). PVRs have a demonstrated switching life of more than 10^{10} operations, and actuation times of less than 100 microseconds. The generation of false thermal voltages by PVRs is much less than that of the best "low thermal" reed relays. Less than 5 milliwatts of control power is normally required and PVRs commonly occupy only a fraction of the volume of comparable EMRs.

Furthermore, International Rectifier PVRs do not require a coil suppression diode. They switch clean without bounce, are not sensitive to position or magnetic fields and, like most solid state devices, are highly resistant to shock and vibration.

International Rectifier's PVR product line summary is given on page B-3. All PVRs are available in DIP packages with voltage ratings up to 300 volts and current ratings as high as 1.0 ampere.

(BOSFET is a registered trademark of International Rectifier)

Microelectronic Relay

Designer's Manual

Data Sheets

The solid state switching devices listed in this Designer's Manual represent International Rectifier's microelectronic power IC relay line as of March 1993. This manual includes information on several new photovoltaic relay (PVR) devices as well as International Rectifier's current family of ChipSwitch solid state relays. Designers are invited to contact IR direct for any additional technical data or applications assistance.

Microelectronic Relay

Designer's Manual

GENERAL INDEX

Microelectronic Relay

Designer's Manual

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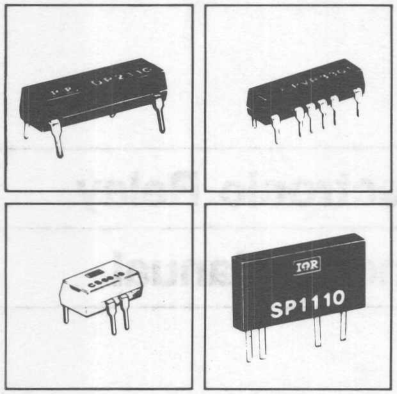
Microelectronic Relay

Designer's Manual

A



Index to standard part numbers listing for each different family-type ChipSwitch and Photovoltaic power IC relay device.

ALPHA-NUMERIC INDEX

Microelectronic Relay

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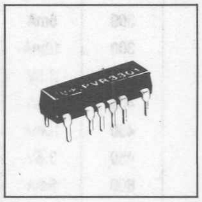
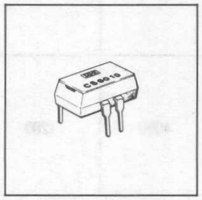
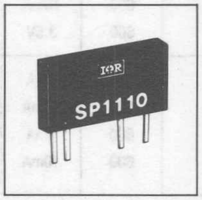
IOR Rectifier

Microelectronic Relay Designer's Manual

SELECTION GUIDE

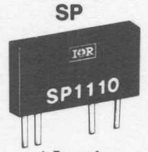
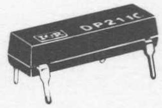
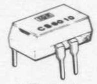




Quick-reference specifications guide to DIP and SIP packages by voltage/current, with wiring diagrams and data sheet pages.

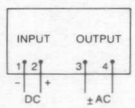
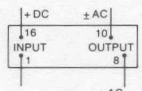
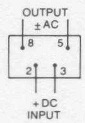
B

Microelectronic Power IC Relays: ChipSwitch Series

International IOR Rectifier

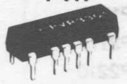
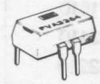
Part Number	Operating Voltage Range V(RMS)	Maximum Load Current @ 40°C A(RMS)	Trans. Overvolt V(Pk)	Turn-On Signal (DC)	Dielectric Strength Input/Output V(RMS)	Minimum Off State dv/dt @ Rated V 25°C V/µs	Maximum Off State Leakage µA	Page Number	Series
SP1110	20-140		300	5mA				C-9	SP 
SP1210	20-140	1.0 Free Standing	300	10mA				C-9	
SP2110	20-280		450	5mA				C-9	
SP2210	20-280		450	10mA	4000	600	10	C-9	
SP6110	20-280	3.0 With Heat Sink	600	5mA				C-9	
SP6210	20-280		600	10mA				C-9	1 Form A
DP1110	20-140		300	5mA				C-5	DP
DP1210	20-140		300	10mA				C-5	
DP1610	20-140		300	3.5V				C-5	
DP2110	20-280		450	5mA				C-5	
DP2210	20-280	1.0	450	10mA	4000	600	10	C-5	
DP2610	20-280		450	3.5V				C-5	
DP6110	20-280		600	5mA				C-5	
DP6210	20-280		600	10mA				C-5	
DP6610	20-280		600	3.5V				C-5	1 Form A
CS5005	20-280		500	5mA				C-1	CS
CS5010	20-280		500	10mA				C-1	
CS6005	20-280	0.3	600	5mA	4000	1200	10	C-1	
CS6010	20-280		600	10mA				C-1	1 Form A

Wiring Diagram

			
Series	**SP**	**DP**	**CS**

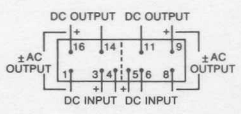
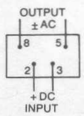
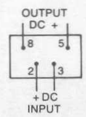
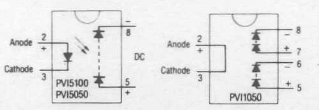
Microelectronic Power IC Relays: Photovoltaic Series

International IOR Rectifier

Part Number (1)	Operating Voltage Range V(Pk)	Max. On-State Res. @ 25°C Ohms		Max Load Current @ 40°C (DC) mA	Nom. Control Current (DC) mA	Min. Off-State Res. Ohms	Dielectric Strength Input/Output V(RMS)	Max. Response Time On/Off μsec	Maximum Thermal Offset Voltage @ 5 mA Control μV	Page Number		Series
		AC/DC	DC									
PVR1300	±100	5.0	1.5	700		10^8		300/50		D-37		PVR
PVR1301	±100	5.0	1.5	700		10^{10}		300/50		D-37		
PVR2300	±200	24	6.0	260	10	10^8	1500	100/50	0.2	D-41		
PVR3300	±300	24	6.0	260		10^8		100/50		D-41		
PVR3301	±300	24	6.0	260		10^{10}		100/50		D-41		2 Form A
PVA1052	±100	35		70	5.0	10^8		25/15		D-1		PVA
PVA1054	±100	35		70	5.0	10^{10}		25/15		D-1		
PVA1352	±100	5.0		315	5.0	10^8		300/50		D-5		
PVA1354	±100	5.0		315	5.0	10^{10}		300/50		D-5		
PVA2352	±200	24		130	5.0	10^8	2500	100/50	0.2	D-13		
PVA3054	±300	160		40	5.0	10^{10}		25/15		D-9		
PVA3055	±300	160		40	5.0	10^{11}		25/15		D-9		
PVA3324	±300	24		130	2.0	10^{10}		100/50		D-13		
PVA3354	±300	24		130	5.0	10^{10}		100/50		D-13		
PVAZ172	±60	0.5		1000	10	10^8	1500	500/8000		D-17		1 Form A
PVD1052	+100		8.0	160	5.0	10^8		25/15		D-21		PVD
PVD1054	+100		8.0	160	5.0	10^{10}		25/15		D-21		
PVD1352	+100		1.5	500	5.0	10^8		300/50		D-25		
PVD1354	+100		1.5	500	5.0	10^{10}	2500	300/50	0.2	D-25		
PVD2352	+200		6.0	220	5.0	10^8		100/50		D-29		
PVD3354	+300		6.0	220	5.0	10^{10}		100/50		D-29		
PVDZ172	+60		0.25	1400	10	10^8	1500	500/8000		D-33		1 Form A

Part Number	Number Outputs	Output Voltage V(DC)	Short Circuit Current μA	Nom. Control Current (DC) mA	Dielectric Strength Innput/Output V(RMS)	Page Number	Series
PVI5050	1	5.0	5.0	10		E-1	PVI
PVI5100	1	5.0	10.0	10	2500	E-1	
PVI1050	2	5.0/10.0	10.0/5.0	10		E-1	

Wiring Diagram

PVR	PVA	PVD	PVI
			

(1) Output for PVD and PVI Series is DC only all others are AC or DC

Microelectronic Relays
Safety Standards Qualifications

International IOR Rectifier

ChipSwitch Part No.	Underwriters Labs Recognition		Canadian Standards Certification		VDE-Prüfstelle Certification	
	Standard	File	Standard	File	Standard	File
SP1110	UL508	E50015	C22.2	Pending	VDE0883/6.80	53105
SP1210		E50015		Pending		53105
SP2110		E50015		Pending		53105
SP2210		E50015		Pending		53105
SP6110		E50015		Pending		53105
SP6210		E50015		Pending		53105
DP1110	UL508	E50015	C22.2	LR32053	VDE0883/6.80	53106
DP1210		E50015		LR32053		53106
DP1610		E50015		LR32053		53106
DP2110		E50015		LR32053		53106
DP2210		E50015		LR32053		53106
DP2610		E50015		LR32053		53106
DP6110		E50015		LR32053		53106
DP6210		E50015		LR32053		53106
DP6610		E50015		LR32053		53106
CS5005	UL508	E50015	C22.2	LR56615	VDE0883/6.80	55448
CS5010		E50015		LR56615		55448
CS6005		E50015		LR56615		55448
CS6010		E50015		LR56615		55448
PVA2352	UL508	E88583	—	—	—	—
PVA3324						
PVA3354						

INTERNATIONAL RECTIFIER IOR

SERIES CS60

Microelectronic
Power IC Relay

300 mA
20-280V AC

ChipSwitch® DIP Relay

C

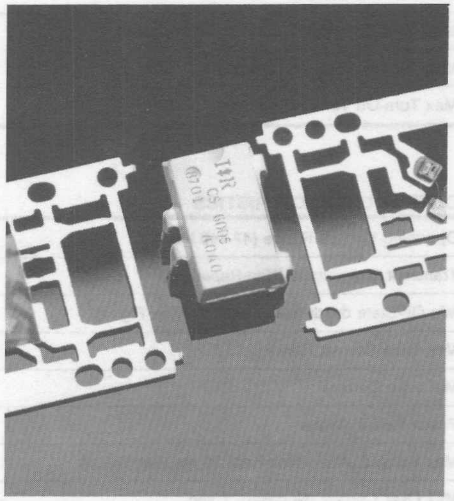
- S³X Power IC Chips
- 5.0 Amp Surge
- 4000V RMS Isolation
- Zero Voltage Turn-On
- EMI Meets FCC/VDE Limits
- Operates Without Snubber
- 1200V/µsec dv/dt
- 10 Microamps Leakage
- UL Recognized - File E50015
- CSA Certified File - LR56615
- VDE File - 55448

GENERAL DESCRIPTION

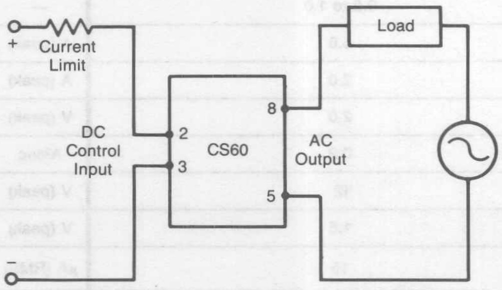
The innovative design of the Series CS60 ChipSwitch solid state relay utilizes the S³X power integrated circuit chip developed by International Rectifier. Two optically activated power ICs are connected in inverse parallel (analogous to back-to-back SCRs) and energized by an isolated light emitting diode (LED). The use of only three components achieves both extreme reliability and miniaturization.

The Series CS60 power IC relays are a normally open configuration with precise zero voltage turn-on and zero current turn off. They conform to the most severe FCC and VDE EMI emission requirements. An active snubber network is integrated within the S³X chips and provides extremely high dv/dt ratings. Therefore, bulky and costly external RC networks are not needed for even low power factor inductive loads. The elimination of external snubber leakages, leaving only the extremely low S³X chip internal leakages, allows perfect operation from very low current loads up to full rating.

These devices are ideally suited for interfacing small AC power loads to microprocessor outputs. Solenoids, lamps, power contactors, small motors, and valves are thereby easily controlled by logic level signals. The Series CS60 units also make excellent high performance drivers for SCR and triac high power output stages.



WIRING DIAGRAM



Part Identification

Part No.	Transient Overvoltage	DC Input Turn-On (mA)
CS6005	600	5.0
CS6010	600	10.0
CS5005	500	5.0
CS5010	500	10.0

IOR

ELECTRICAL SPECIFICATIONS ($-30°C \le T_A \le 85°C$ unless otherwise specified)

GENERAL CHARACTERISTICS

Dielectric Strength — Input/Output		4000	V (RMS)
Insulation Resistance @ 500VDC — Input/Output		10^{12}	Ohms
Tracking Resistance (VDE Test)		KB100/A	—
Max Capacitance — Input/Output		1.0	pF
Ambient Temperature Range	Operating	−30 to 85	°C
	Storage	−40 to 100	°C
Lead Temperature (1.6 mm below seating plane) for 10 sec.		260	°C

ELECTRICAL SPECIFICATIONS ($-30°C \le T_A \le 85°C$ unless otherwise specified)

INPUT CHARACTERISTICS	CS6005	CS6010	CS5005	CS5010	Units
Control Current Range (Caution: Current limit input LED) See Fig. 3	5-25	10-25	5-25	10-25	mA (DC)
Max Reverse Voltage	7.0				V (DC)
Max Turn-On Current	5.0	10	5.0	10	mA (DC)
Min Turn-Off Current	0.25				mA (DC)
Max Turn-On Time (47-440 Hz)	0.5				Cycle
Max Turn-Off Time (47-440 Hz)	0.5				Cycle

OUTPUT CHARACTERISTICS

	CS6005 / CS6010	CS5005 / CS5010	
Operating Voltage Range (47-440 Hz)	20-280	20-280	V (RMS)
Transient Overvoltage (Non-Repetitive)	600	500	V (peak)
Min Off-State dv/dt (static)① 25°C (See Fig. 4)	1200		V/μs
Max Load Current (See Fig.1)②	300		mA (RMS)
Min Load Current	0.5		mA (RMS)
Power Factor Range	0.2 to 1.0		—
Max Surge Current (Non-Rep) 20 ms (See Fig. 2)	5.0		A (peak)
Max Over Current (Non-Rep) 1 sec	2.0		A (peak)
Max On-State Voltage Drop @ 0.5A	2.0		V (peak)
Max I^2T for Fusing (.01 sec)	0.2		A^2sec
Max Zero Voltage Turn-On	12		V (peak)
Max Peak Repetitive Turn-On Voltage @ 15 mA	1.5		V (peak)
Max Off-Stage Leakage Current ②@ Max. Operating Voltage, 25°C	10		μA (RMS)

Data and Specifications subject to change without notice.

GENERAL NOTES: ① Off-state dv / dt test method per EIA/NARM standard RS -443 with V_p equal to the instantaneous peak of the maximum operating voltage. ② LED input current of zero mA.

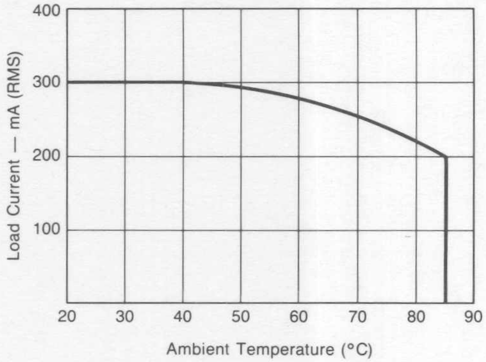


Figure 1. Derating Curve

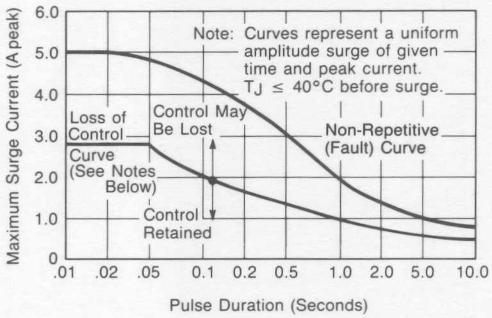


Figure 2. Maximum Allowable Surge (See Notes Below*)

*A surge exceeding the upper (Non-Repetitive Fault) curve can cause catastrophic failure. This limit is an absolute maximum rating and should be used in determining current limit or fusing protection techniques. Repetitions should not exceed 100 times during the normal operating life.

Exceeding the limit of the lower (Loss of Control) curve can cause momentary, but non-catastrophic, inability to instantaneously turn-off the load. Good application practice holds the normal, repetitive load inrush currents below this limit.

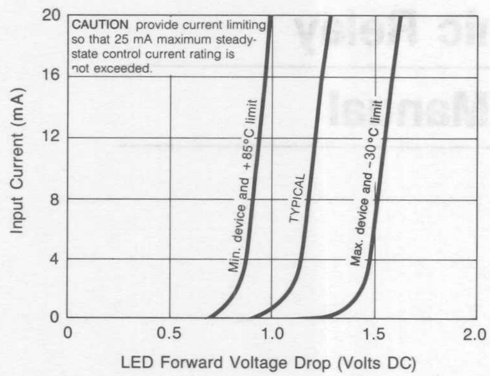


Figure 3. Input Characteristics (Current Controlled)

C

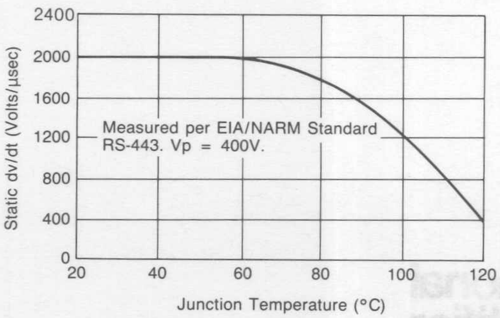
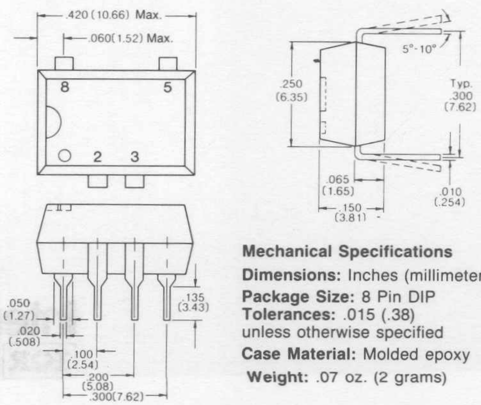


Figure 4. Typical Static dv/dt Performance



Mechanical Specifications

Dimensions: Inches (millimeters)

Package Size: 8 Pin DIP

Tolerances: .015 (.38) unless otherwise specified

Case Material: Molded epoxy

Weight: .07 oz. (2 grams)

Microelectronic Relay

Designer's Manual

International
IOR Rectifier

INTERNATIONAL RECTIFIER IOR

SERIES DP

Microelectronic Power IC Relay

1 Amp
20-280V AC

ChipSwitch® DIP Relay

GENERAL DESCRIPTION

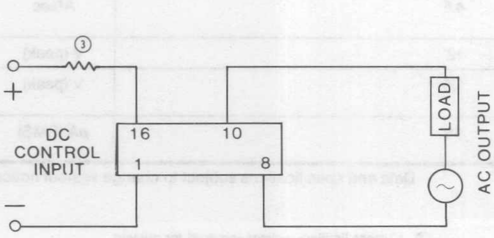
The ChipSwitch DIP uses the exclusive International Rectifier S^3X power integrated circuit technology to form a fully functioning solid-state relay. The S^3X technology combines MOS and bipolar processes, derived from IRs HEXFET® power MOSFET designs, to eliminate the need for both discrete components and hybrid circuits. The basic ChipSwitch DIP consists simply of two identical power integrated circuits connected in inverse parallel (analogous to back-to-back SCRs) for AC control plus an isolated light emitting diode (LED) for actuation. Voltage controlled models with an internal resistor to limit the control current are also available

Extreme reliability is achieved by the reduction of component count from approximately 20 discrete components in a conventional SSR to 3 basic components in the ChipSwitch. The power integrated circuits are fabricated in IR's advanced MOSFET fabrication plant which achieves standards of cleanliness, precision, and consistency unprecedented in the manufacture of power semiconductors.

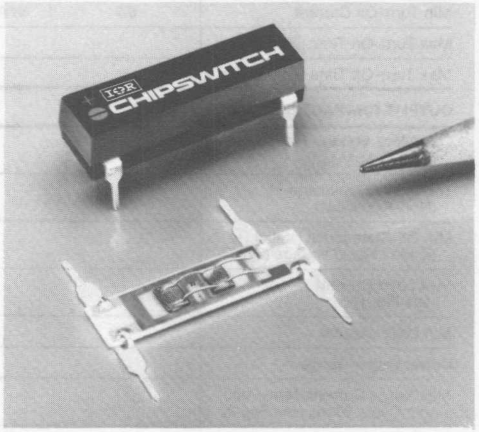
The ChipSwitch is a normally open SSR of 1.0 ampere rating with precise zero voltage turn-on and zero current turn-off. EMI emission conforms to the most severe FCC and VDE requirements.

The devices are ideally suited for interfacing microprocessors to AC loads such as small motors, lamps, solenoids, valves, and high power motor starters. The economy of the ChipSwitch allows the in-house manufacturer to replace assemblies of triacs, triac drivers and associated components with a highly reliable, miniature, standard SSR.

WIRING DIAGRAM



- S^3X Power IC Chips ■
- 30 Amps Surge ■
- 4000V RMS Isolation ■
- Zero Voltage Turn-On ■
- EMI Meets FCC/VDE Limits ■
- Operates Without Snubber ■
- 600V/μsec dv/dt ■
- 10 Microamps Leakage ■
- TO-116 Pinout ■
- UL Recognized - File E50015 ■
- CSA Certified File - LR32053 ■
- VDE File - 53106 ■



C

Part Identification

Part No.	Transient Overvoltage (Vpk)	Operating Voltage (VRMS)	DC Input Turn-On
DP1110			5 mA
DP1210	300	20-140	10 mA
DP1610			3.5 V
DP2110			5 mA
DP2210	450	20-280	10 mA
DP2610			3.5 V
DP6110			5 mA
DP6210	600	20-280	10 mA
DP6610			3.5 V

ChipSwitch DIP

GENERAL CHARACTERISTICS

ELECTRICAL SPECIFICATIONS (−30°C ≤ T_A ≤ 85°C unless otherwise specified)

Dielectric Strength — Input/Output		4000	V (RMS)
Insulation Resistance @ 500VDC — Input/Output		10^{12}	Ohms
Tracking Resistance (VDE Test)		KB 100/A	—
Max Capacitance — Input/Output		2.0	pF
Ambient Temperature Range	Operating	−30 to 85	°C
	Storage	−40 to 100	°C
Lead Temperature (1.6 mm below seating plane) for 10 sec.		260	°C

INPUT CHARACTERISTICS	DP1110	DP1210	DP1610	DP2110	DP2210	DP2610	DP6110	DP6210	DP6610	Units
Control Current Range ② (see Fig. 3)	5-25	10-25	N/A	5-25	10-25	N/A	5-25	10-25	N/A	mA (DC)
Control Voltage Range (see Fig. 4)	N/A		3.5-7	N/A		3.5-7	N/A		3.5-7	V (DC)
Max Reverse Voltage	7.0									V (DC)
Max Turn-On Voltage	N/A		3.5	N/A		3.5	N/A		3.5	V (DC)
Min Turn-Off Voltage	N/A		0.8	N/A		0.8	N/A		0.8	V (DC)
Min Input Impedance	N/A		270	N/A		270	N/A		270	Ohms
Max Turn-On Current	5.0	10	N/A	5.0	10	N/A	5.0	10	N/A	mA (DC)
Min Turn-Off Current	0.5		N/A	0.5		N/A	0.5		N/A	mA (DC)
Max Turn-On Time (60 Hz)	8.3									mSec
Max Turn-Off Time (60 Hz)	8.3									mSec

OUTPUT CHARACTERISTICS	DP1110 / DP1210 / DP1610	DP2110 / DP2210 / DP2610	DP6110 / DP6210 / DP6610	Units
Operating Voltage Range (47-440 Hz)	20-140	20-280	20-280	V (RMS)
Transient Overvoltage (Non-Repetitive)	300	450	600	V (peak)
Min Off-State dv/dt (static) ① @ Max Rated Voltage (25°C)		600		V/μs
Max Load Current (see Fig. 1)		1.0		A (RMS)
Min Load Current		0.5		mA (RMS)
Power Factor Range		0.2 to 1		—
Max Surge Current (Non-Rep.) Single Cycle 20 ms (see Fig. 2)		30		A (peak)
Max Over Current (Non-Rep.) 1 sec		7.5		A (peak)
Max On-State Voltage Drop @ Rated Current		1.5		V (peak)
Max I^2T for Fusing (.01 sec)		4.5		A^2sec
Max Zero Voltage Turn-On		12		V (peak)
Max Peak Repetitive Turn-On Voltage @ 20mA Input		1.5		V (peak)
Max Off-State Leakage Current③ @ Max. Operating Voltage, 25°C		10		μA (RMS)

Data and specifications subject to change without notice.

GENERAL NOTES

① Off-state dv/dt test method per EIA/NARM standard RS-443 with V_p equal to the instantaneous peak of the maximum operating voltage.

② Current limiting resistor required for current controlled models.

③ LED input current of zero MA.

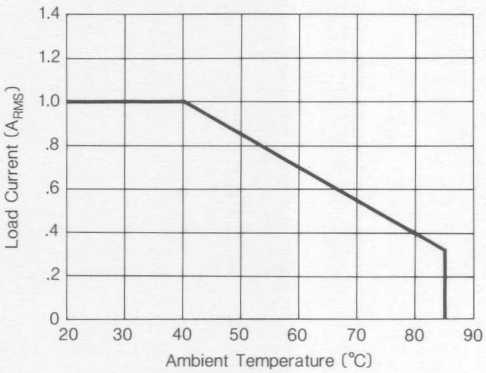


Figure 1. Derating Curve

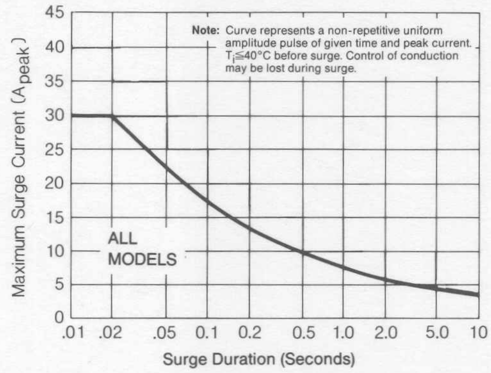


Figure 2. Max. Allowable Surge

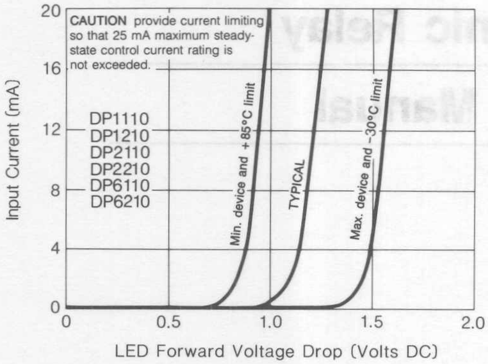


Figure 3. Input Characteristics (Current Controlled)

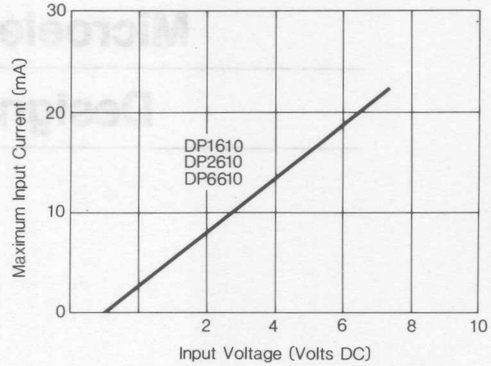


Figure 4. Input Characteristics (Voltage Controlled)

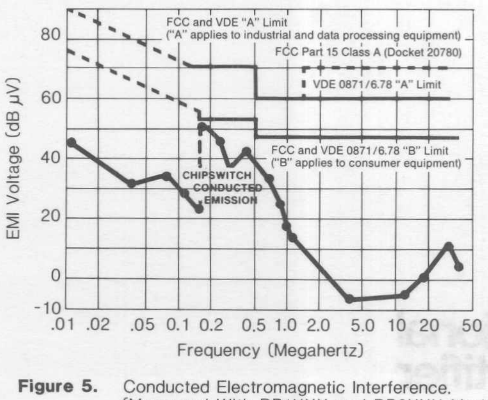
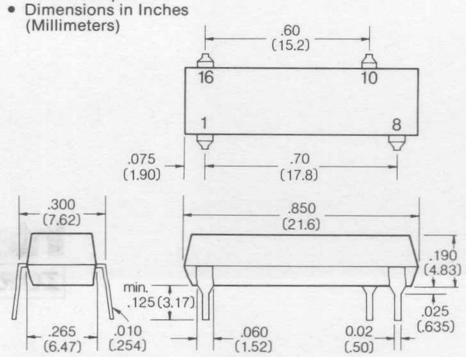


Figure 5. Conducted Electromagnetic Interference. (Measured With DP1XXX and DP2XXX Models)

MECHANICAL SPECIFICATIONS

- TO-116 Pinout
- Tolerances .015 (.38) unless otherwise specified
- Dimensions in Inches (Millimeters)



C

Microelectronic Relay

Designer's Manual

International
IOR Rectifier

Data Sheet No. PD-1.018B

INTERNATIONAL RECTIFIER IOR

SERIES SP

Microelectronic Power IC Relay

1.0 Amp (Free Standing)
3.0 Amps (with Heat Management
20-280 VAC

ChipSwitch® SIP Relay

- S^3X Power IC Chips
- 30-40 Amps Surge
- 4000V RMS Isolation
- Zero Voltage Turn-On
- EMI Meets FCC/VDE Limits
- Operates Without Snubber
- 600V/μsec dv/dt
- 10 Microamps Leakage
- UL Recognized - File E50015
- CSA Approval Pending
- VDE File - 53105

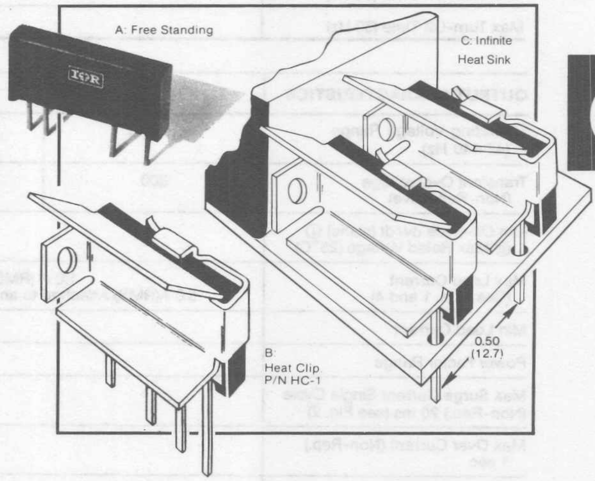
GENERAL DESCRIPTION

The ChipSwitch SIP uses exclusive International Rectifier S^3X power integrated circuit technology to form a fully functioning solid-state relay. The S^3X technology combines MOS and bipolar processes, derived from IRs HEXFET® power MOSFET designs, to eliminate the need for both discrete components and hybrid circuits. The basic ChipSwitch SIP consists of two identical power integrated circuits connected in inverse parallel (analogous to back-to-back SCRs) for AC control plus an isolated light emitting diode (LED) for actuation.

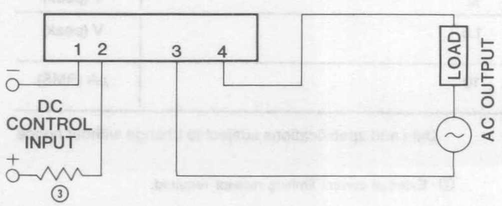
Extreme reliability is achieved by the reduction of component count from approximately 20 discrete components in a conventional SSR to 3 basic components in the ChipSwitch. The power integrated circuits are fabricated in IR's advanced MOSFET fabrication plant which achieves standards of cleanliness, precision, and consistency unprecedented in the manufacture of power semiconductors.

The ChipSwitch SIP is a normally open SSR of 1 to 3 Amps rating with precise zero voltage turn-on and zero current turn-off. EMI emission conforms to the most severe FCC and VDE requirements.

The devices are ideally suited for interfacing microprocessors to AC loads such as small motors, lamps, solenoids, valves, and high power motor starters. The economy of the ChipSwitch SIP allows the in-house manufacturer to replace assemblies of triacs, triac drivers and associated components with a highly reliable, miniature, standard SSR.



WIRING DIAGRAM



Part Identification

Part No.	Transient Overvoltage (VPK)	Operating Voltage (VRMS)	DC Input Turn-On
SP1110 SP1210	300	20-140	5 mA 10 mA
SP2110 SP2210	450	20-280	5 mA 10 mA
SP6110 SP6210	600	20-280	5 mA 10 mA

ChipSwitch SIP

ELECTRICAL SPECIFICATIONS (−30°C ≤ T_A ≤ 85°C unless otherwise specified)

GENERAL CHARACTERISTICS			Units
Dielectric Strength — Input/Output		4000	V (RMS)
Insulation Resistance @ 500VDC — Input/Output		10^{12}	Ohms
Tracking Resistance (VDE Test)		KB 100/A	—
Max Capacitance — Input/Output		2.0	pF
Ambient Temperature Range	Operating	−30 to 85	°C
	Storage	−40 to 100	°C
Lead Temperature (1.6 mm below seating plane) for 10 sec.		260	°C

INPUT CHARACTERISTICS	SP1110	SP1210	SP2110	SP2210	SP6110	SP6210	Units
Control Current Range ② (see Fig. 3)	5-25	10-25	5-25	10-25	5-25	10-25	mA (DC)
Max Reverse Voltage	7.0						V (DC)
Max Turn-On Current	5.0	10	5.0	10	5.0	10	mA (DC)
Min. Turn-Off Current	0.5						mA (DC)
Max Turn-On Time (60 Hz)	8.3						mSec
Max Turn-Off Time (60 Hz)	8.3						mSec

OUTPUT CHARACTERISTICS				Units
Operating Voltage Range (47-440 Hz)	20-140	20-280	20-280	V (RMS)
Transient Overvoltage (Non-Repetitive)	300	450	600	V (peak)
Min Off-State dv/dt (static) ① @ Max Rated Voltage (25°C)	600			V/μs
Max Load Current (See Figs. 1 and 4)	1.0 A (RMS) Free Standing in 40°C Air. 3.0 A(RMS) Attached to an infinite heat sink @ 40°C (Θ_{JS}= 7°C/Watt)			A (RMS)
Min Load Current	0.5			mA (RMS)
Power Factor Range	0.2 to 1.0			
Max Surge Current Single Cycle (Non-Rep.) 20 ms (see Fig. 2)	30			A (peak)
Max Over Current (Non-Rep.) 1 sec	7.5			A (peak)
Max On-State Voltage Drop @ 1.0A (RMS)	1.5			V (peak)
Max I^2T for Fusing (.01 sec)	4.5			A^2sec
Max Zero Voltage Turn-On	12			V (peak)
Max Peak Repetitive Turn-On Voltage @ 20mA Input	1.5			V (peak)
Max Off-State Leakage Current③ @ Max. Operating Voltage, 25°C	10			μA (RMS)

GENERAL NOTES

Data and specifications subject to change without notice.

① Off-state dv/dt test method per EIA/NARM standard RS-443 with V_P equal to the instantaneous peak of the maximum operating voltage.

② External current limiting resistor required.

③ LED input current of zero MA.

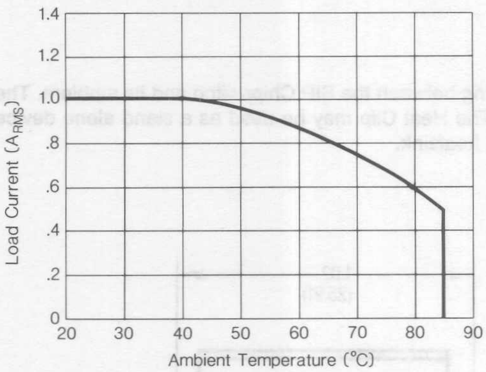


Figure 1. Derating Curve, Free Standing

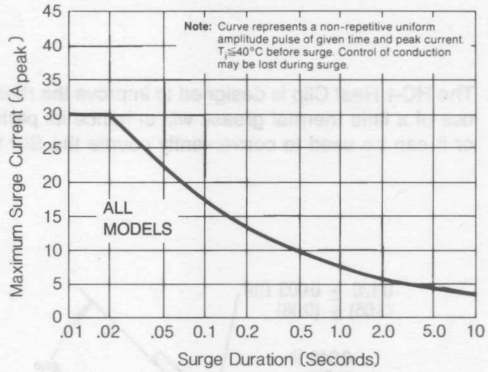


Figure 2. Maximum Allowable Surge

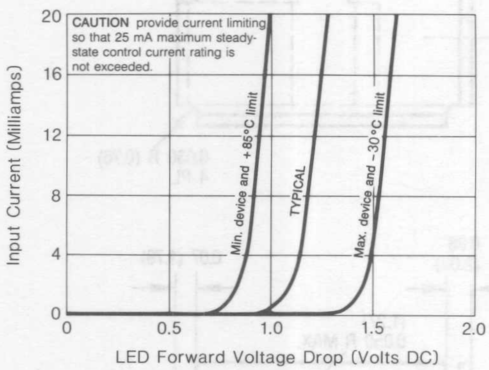


Figure 3. Input Characteristics (Current Controlled)

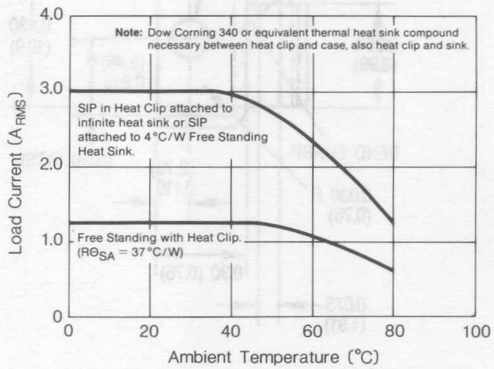


Figure 4. Load Current Under Heat Management

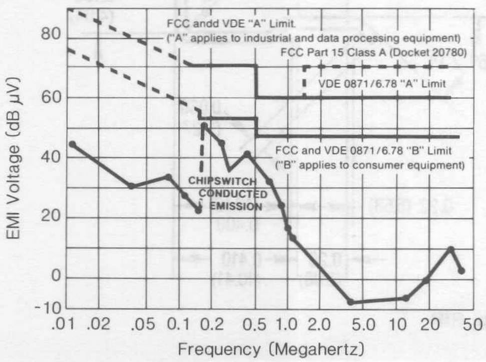
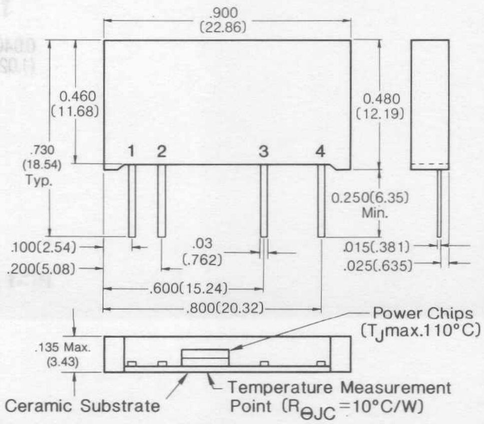


Figure 5. Conducted Electromagnetic Interference. (Measured With SP1XXX and SP2XXX models).

MECHANICAL SPECIFICATIONS

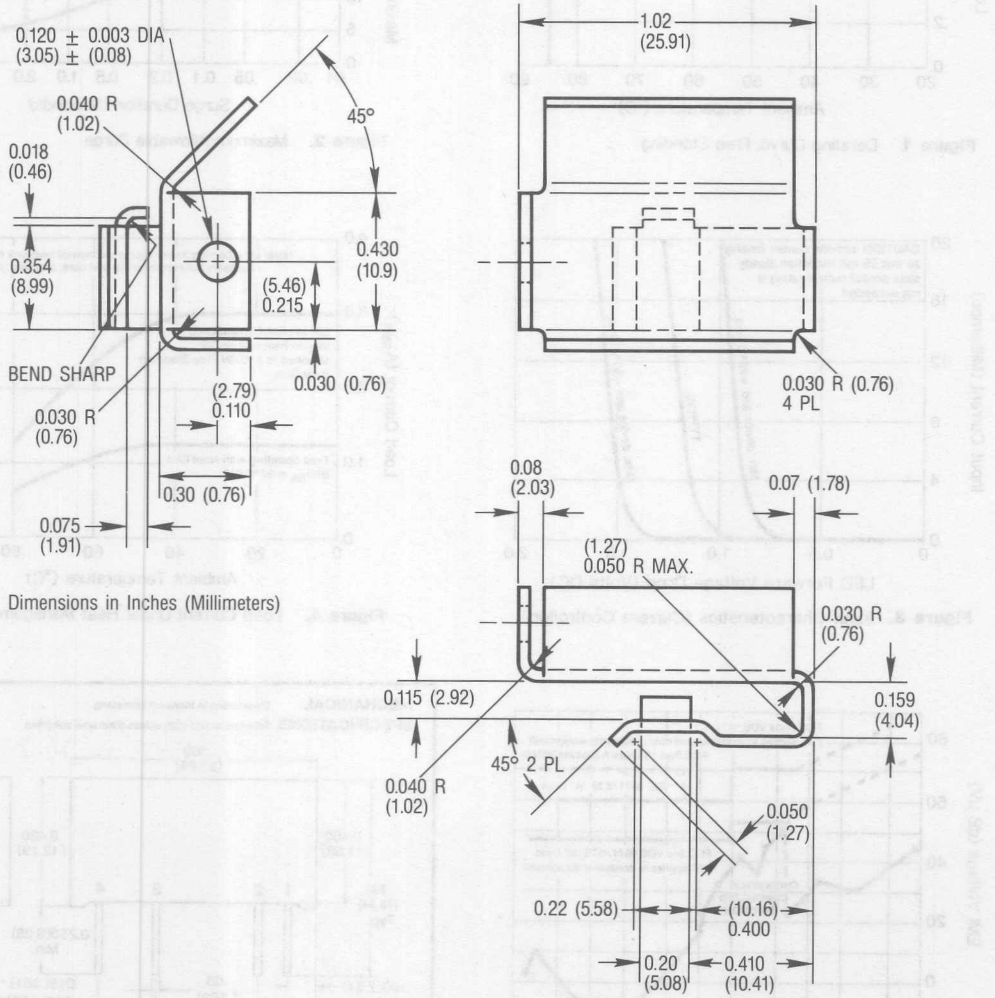
Dimensions in Inches (Millimeters)

Tolerances: 015 (.38) unless otherwise specified.



C

The HC-1 Heat Clip is designed to improve the thermal coupling between the SIP Chipswitch and its ambient. The use of a little thermal grease will enhance its performance. The Heat Clip may be used as a stand alone device or it can be used to conveniently couple the SIP to a larger heatsink.



HC-1 Heat Clip, SIP

INTERNATIONAL RECTIFIER IOR

SERIES PVA10

Microelectronic
Power IC Relay

Single Pole, 70 mA
0-100V AC/DC

BOSFET® PhotoVoltaic Relay

GENERAL DESCRIPTION

The Photovoltaic AC Relay (PVA) is a single-pole, normally open solid state replacement for electro-mechanical relays used for general purpose switching of analog signals. It utilizes as an output switch a unique bidirectional (AC or DC) MOSFET power IC termed a BOSFET. The BOSFET is controlled by a photovoltaic generator of novel construction, which is energized by radiation from a dielectrically isolated light emitting diode (LED).

PVA FEATURES

The PVA overcomes the limitations of both conventional and reed electromechanical relays by offering the solid state advantages of long life, high operating speed, low pick-up power, bounce free operation, low thermal voltages and miniaturization. These advantages allow product improvement and design innovations in many applications such as process control, multiplexing, telecommunications, automatic test equipment, and data acquisition.

The PVA can switch analog signals from thermocouple level to 100 volts peak AC or DC polarity. Signal frequencies into the RF range are easily controlled and switching rates up to 18 kHz are achievable. The extremely small thermally generated offset voltages allow increased measurement accuracies.

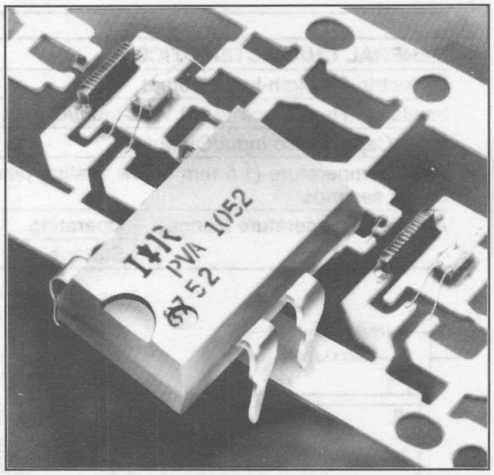
Unique silicon technology developed by International Rectifier forms the heart of the PVA. The monolithic BOSFET contains a bidirectional N channel power MOSFET output structure. In addition, this power IC chip has input circuitry for fast turn-off and gate protection functions. This section of the BOSFET chip utilizes both bipolar and MOS technology to form NPN transistors, P channel MOSFETs, resistors, diodes and capacitors.

The photovoltaic generator similarly utilizes a unique International Rectifier alloyed multijunction structure. The excellent current conversion efficiency of this technique results in the very fast response of the PVA microelectronic power IC relay.

This advanced semiconductor technology has created a radically new control device. Designers can now develop switching systems to new standards of electrical performance and mechanical compactness.

(BOSFET is a trademark of International Rectifier)

- BOSFET Power IC
- 10^{10} Operations
- 25 µSec Operating Time
- 0.2 µVolt Thermal Offset
- 3 milliwatts Pick-Up Power
- 1000 V/µsec dv/dt
- Bounce Free
- 8-Pin DIP Package
- -40°C to 85°C



D

Part Identification

Part No.	Operating Voltage DC	Sensitivity	Off-State Resistance
PVA1052	0-100V	5 mA	10^8 Ohms
PVA1054			10^{10} Ohms

BOSFET PVA10 PhotoVoltaic Relay

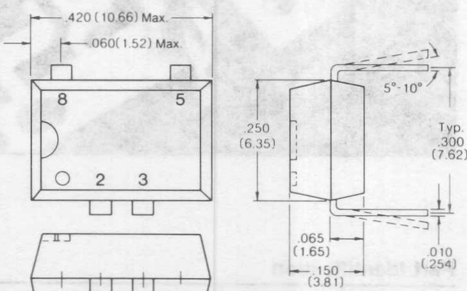
IOR

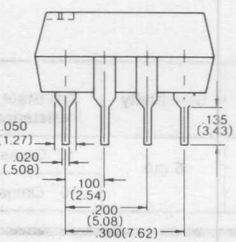
ELECTRICAL SPECIFICATIONS ($-40°C \leq T_A \leq 85°C$ unless otherwise specified)

INPUT CHARACTERISTICS	PART NUMBERS		UNITS
	PVA1052	PVA1054	
Min. Control Current: (See Figs. 1 & 2)			(DC)
For 25 mA Continuous Load Current.	2.0		mA @ 25°C
For 50 mA Continuous Load Current.	5.0		mA @ 40°C
For 15 mA Continuous Load Current.	5.0		mA @ 80°C
Max. Control Current for Off-State Resistance at 25°C	10		μA (DC)
Control Current Range (Caution: Current limit input LED. (See Fig. 6)	2.0 to 25		mA (DC)
Max. Reverse Voltage	7.0		V (DC)

OUTPUT CHARACTERISTICS	PVA1052	PVA1054	
Operating Voltage Range	0 ± 100		V (peak)
Max. Load Current 40°C (See Fig. 1 & 2)	70		mA (DC)
Response Time @ 25°C (See Fig. 7 and 8)			
Max. $T_{(on)}$ @ 12 mA Control, 50 mA Load, 50 VDC	25		μs
Max. $T_{(off)}$ @ 12 mA Control, 50 mA Load, 50 VDC	15		μs
Max. On-State Resistance 25°C (Pulsed) (See Fig. 4) (50 mA Load 5 mA Control)	35		Ohms
Min. Off-State Resistance at 25°C @ 80 VDC (See Fig. 5)	10^8	10^{10}	Ohms
Max. Thermal Offset Voltage @ 5.0 mA Control	0.2		μ volts
Min. Off-State dv/dt	1000		V/μs
Output Capacitance	3		pF @ 50 VDC

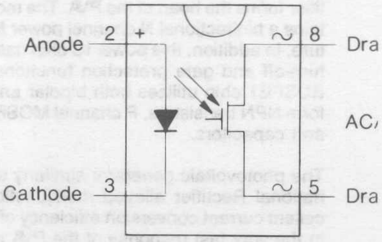
GENERAL CHARACTERISTICS		ALL MODELS	
Dielectric Strength-Input/Output		2500	V (RMS)
Insulation Resistance @ 90 VDC-Input/Output		10^{12} @ 25°C - 50% RH	Ohms
Max. Capacitance-Input/Output		1.0	pf
Lead Temperature (1.6 mm below seating plane) for 10 seconds		260	°C
Ambient Temperature Range:	Operating	-40 to 85	°C
	Storage	-40 to 100	°C



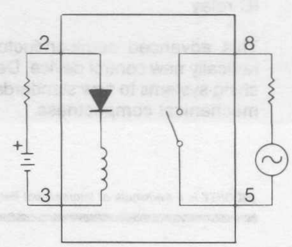


Mechanical Specifications
Dimensions: Inches (mm)
Package Size: 8 Pin DIP
Tolerances: .015 (.38) unless otherwise specified
Case Material: Molded epoxy
Weight: .07 oz. (2 grams)

Wiring Diagram



Electromechanical Analogy



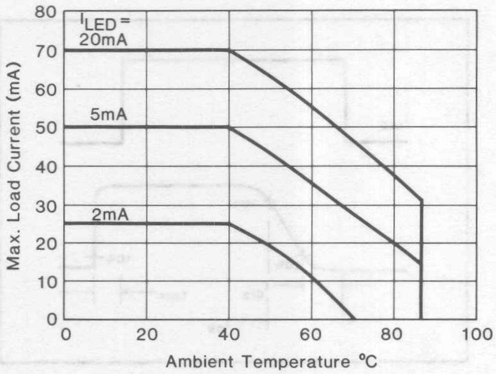


Figure 1. Current Derating Curves

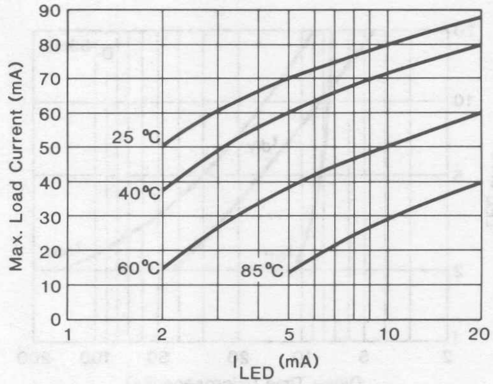


Figure 2. Typical Control Current Requirements

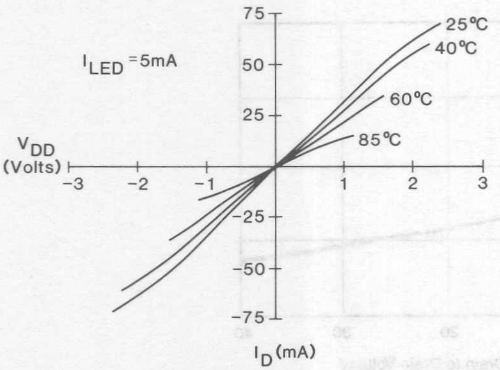


Figure 3. Typical On Characteristics

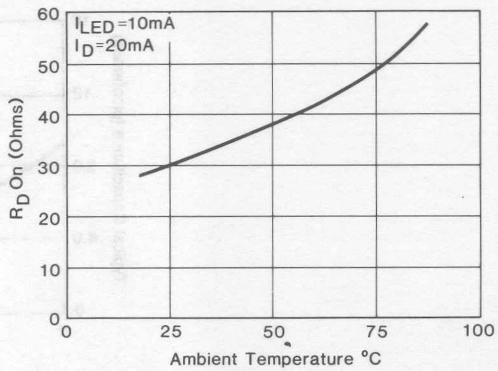


Figure 4. Typical On-Resistance

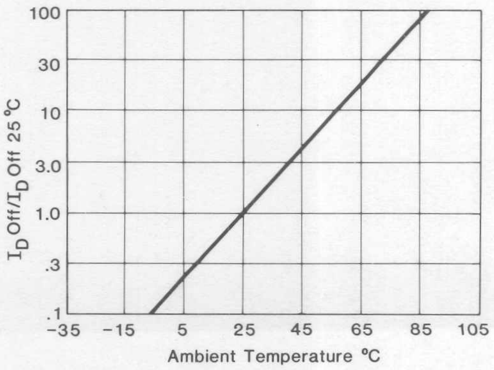


Figure 5. Normalized Off-State Leakage

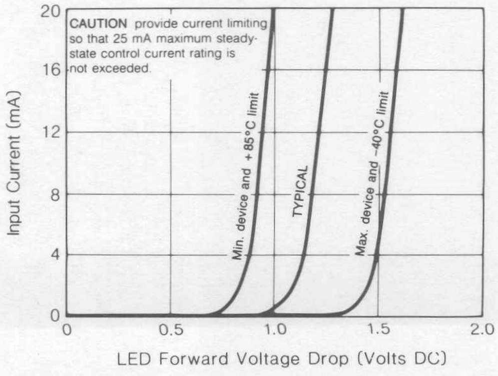


Figure 6. Input Characteristics (Current Controlled)

D

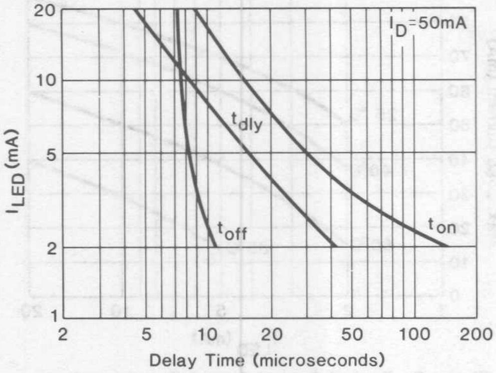


Figure 7. Typical Delay Times

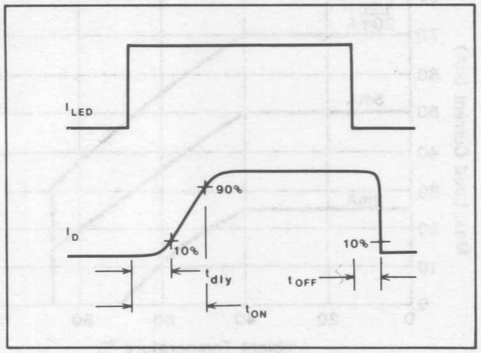


Figure 8. Delay Time Definitions

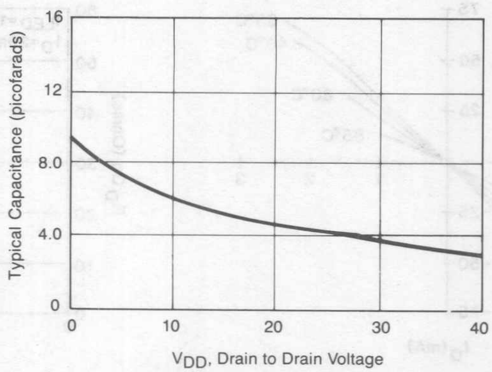


Figure 9. Typical Output Capacitance

INTERNATIONAL RECTIFIER IOR

SERIES PVA13

Microelectronic Power IC Relay

Single Pole, 300 mA
0-100V AC/DC

BOSFET® PhotoVoltaic Relay

GENERAL DESCRIPTION

The Photovoltaic AC Relay (PVA) is a single-pole, normally open solid state replacement for electro-mechanical relays used for general purpose switching of analog signals. It utilizes as an output switch a unique bidirectional (AC or DC) MOSFET power IC termed a BOSFET. The BOSFET is controlled by a photovoltaic generator of novel construction, which is energized by radiation from a dielectrically isolated light emitting diode (LED).

PVA FEATURES

The PVA overcomes the limitations of both conventional and reed electromechanical relays by offering the solid state advantages of long life, high operating speed, low pick-up power, bounce free operation, low thermal voltages and miniaturization. These advantages allow product improvement and design innovations in many applications such as process control, multiplexing, telecommunications, automatic test equipment, and data acquisition.

The PVA can switch analog signals from thermocouple level to 100 volts peak AC or DC polarity. Signal frequencies into the RF range are easily controlled and switching rates up to 2 kHz are achievable. The extremely small thermally generated offset voltages allow increased measurement accuracies.

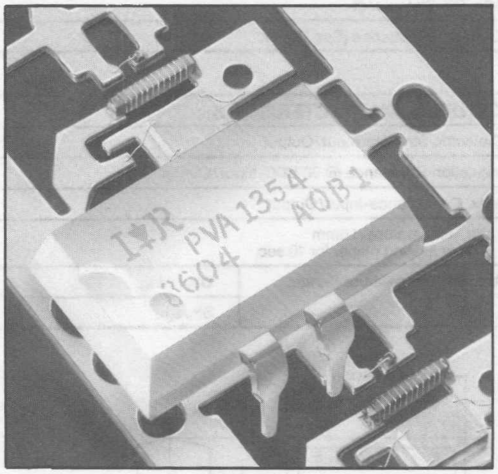
Unique silicon technology developed by International Rectifier forms the heart of the PVA. The monolithic BOSFET contains a bidirectional N channel power MOSFET output structure. In addition, this power IC chip has input circuitry for fast turn-off and gate protection functions. This section of the BOSFET chip utilizes both bipolar and MOS technology to form NPN transistors, P channel MOSFETs, resistors, diodes and capacitors.

The photovoltaic generator similarly utilizes a unique International Rectifier alloyed multi-junction structure. The excellent current conversion efficiency of this technique results in the very fast response of the PVA microelectronic power IC relay.

This advanced semiconductor technology has created a radically new control device. Designers can now develop switching systems to new standards of electrical performance and mechanical compactness.

(*BOSFET is a trademark of International Rectifier*)

- **BOSFET Power IC**
- **10^{10} Operations**
- **300 μSec Operating Time**
- **0.2 μVolt Thermal Offset**
- **3 milliwatts Pick-Up Power**
- **1000 V/μsec dv/dt**
- **Bounce Free**
- **8-Pin DIP Package**
- **-40° C to 85° C**



Part Identification

Part No.	Operating Voltage AC/DC	Sensitivity	Off-State Resistance
PVA1352	0-100V	5 mA	10^8 Ohms
PVA1354			10^{10} Ohms

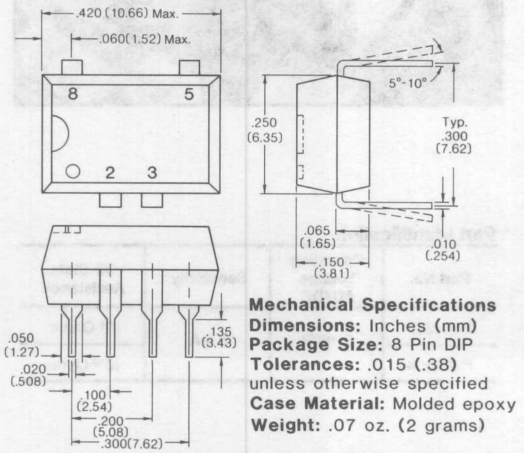
BOSFET PVA13 PhotoVoltaic Relay

ELECTRICAL SPECIFICATIONS (−40°C ≤ T_A ≤ 85°C unless otherwise specified)

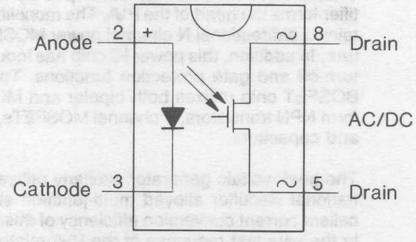
INPUT CHARACTERISTICS	PART NUMBERS		UNITS
	PVA1352	PVA1354	
Min. Control Current: (See Figs. 1 & 2) For 200 mA Continuous Load Current	2.0		(DC) mA @ 25°C
For 250 mA Continuous Load Current	5.0		mA @ 40°C
For 125 mA Continuous Load Current	5.0		mA @ 85°C
Max. Control Current for Off-State Resistance at 25°C	10		μA (DC)
Control Current Range (Caution: Current limit input LED. See Fig. 6)	2.0 to 25		mA (DC)
Max Reverse Voltage	7.0		V (DC)

OUTPUT CHARACTERISTICS	PVA1352	PVA1354	
Operating Voltage Range	0 ± 100		V (peak)
Max. Load Current 40°C (See Fig. 1 and 2)	315		mA (DC)
Response Time @ 25°C (See Fig. 7 and 8)			
Max. $T_{(on)}$ @ 12 mA Control, 50 mA load, 50 VDC	300		μs
Max. $T_{(off)}$ @ 12 mA Control, 50 mA load, 50 VDC	50		μs
Max. On-State Resistance 25°C (pulsed) (See Fig. 4) 50mA Load 5mA Control)	5		Ohms
Min. Off-State Resistance at 25°C @ 80 VDC (See Fig. 5)	10^8	10^{10}	Ohms
Max. Thermal Offset Voltage, @ 5.0 mA Control	0.2		μ volts
Min. Off-State dv/dt	1000		V/μs
Output Capacitance (See Fig. 9)	15		pF @ 50 VDC

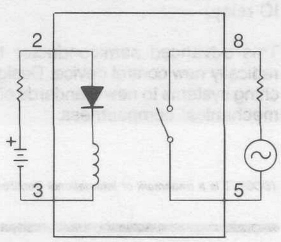
GENERAL CHARACTERISTICS		ALL MODELS	
Dielectric Strength-Input/Output		2500	V (RMS)
Insulation Resistance @ 90 VDC-Input/Output		10^{12} @ 25°C − 50% RH	Ohms
Max. Capacitance-Input/Output		1.0	pF
Lead Temperature (1.6mm below seating plane) for 10 sec.		260	°C
Ambient Temperature Range:	Operating	−40 to 85	°C
	Storage	−40 to 100	°C



Mechanical Specifications
Dimensions: Inches (mm)
Package Size: 8 Pin DIP
Tolerances: .015 (.38) unless otherwise specified
Case Material: Molded epoxy
Weight: .07 oz. (2 grams)



Wiring Diagram



Electromechanical Analogy

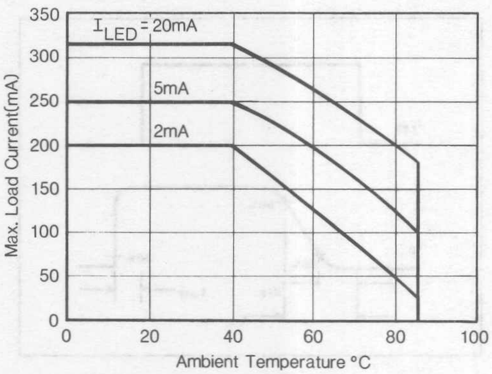


Figure 1. Current Derating Curves

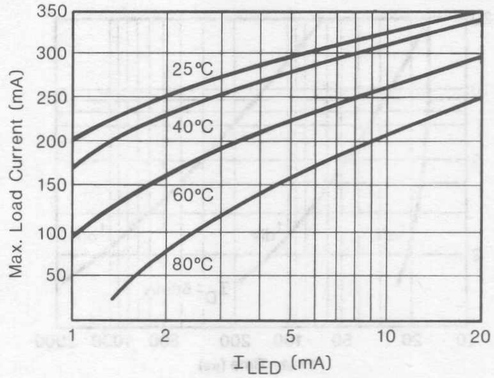


Figure 2. Typical Control Current Requirements

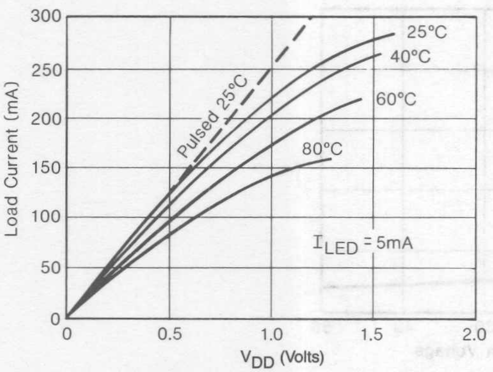


Figure 3. Typical On Characteristics

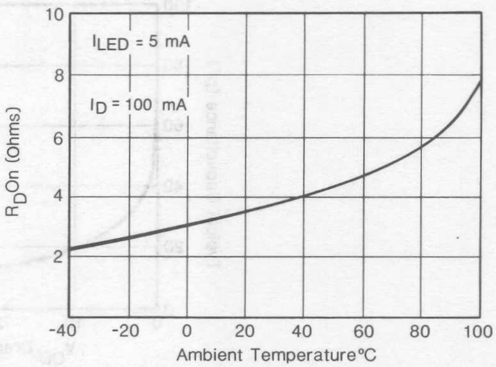


Figure 4. Typical On-Resistance

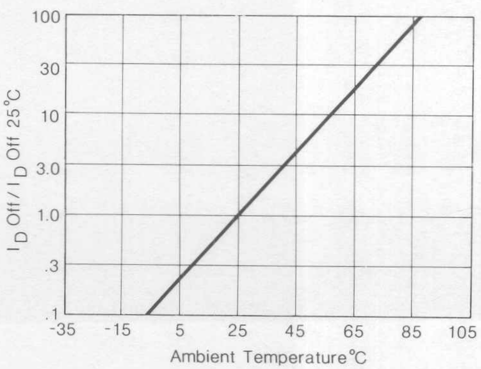


Figure 5. Normalized Off-State Leakage

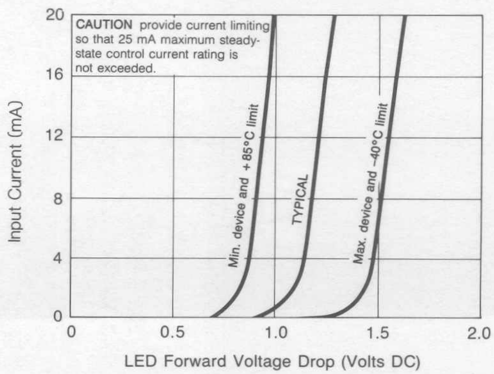


Figure 6. Input Characteristics (Current Controlled)

D

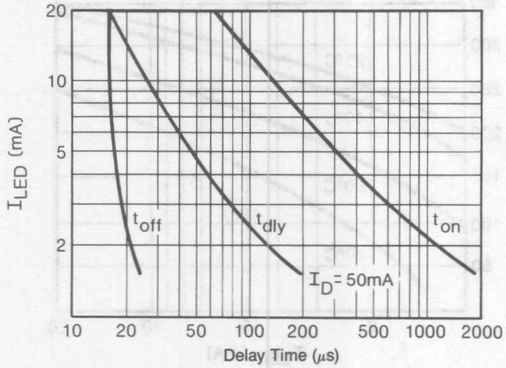


Figure 7. Typical Delay Times

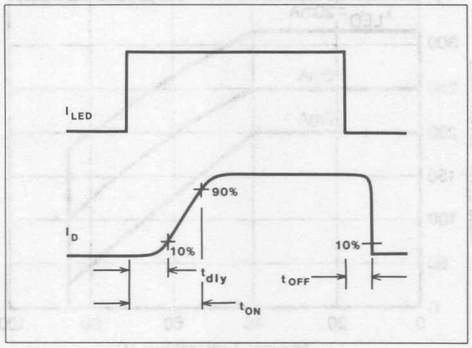


Figure 8. Delay Time Definitions

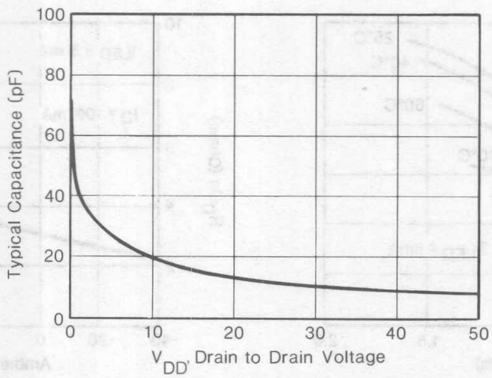


Figure 9. Typical Output Capacitance

INTERNATIONAL RECTIFIER IOR

SERIES PVA30

Microelectronic Power IC Relay

Single Pole, 40 mA
0-300V AC/DC

BOSFET® PhotoVoltaic Relay

GENERAL DESCRIPTION

The Photovoltaic AC Relay (PVA) is a single-pole, normally open solid state replacement for electro-mechanical relays used for general purpose switching of analog signals. It utilizes as an output switch a unique bidirectional (AC or DC) MOSFET power IC termed a BOSFET. The BOSFET is controlled by a photovoltaic generator of novel construction, which is energized by radiation from a dielectrically isolated light emitting diode (LED).

PVD FEATURES

The PVA30 Series combines very low solid state output capacitance, very high off-state resistance and very fast response. These Photovoltaic Relays are designed specifically to accurately switch low level signals in high performance instrumentation systems.

The PVA overcomes the limitations of both conventional and reed electromechanical relays by offering the solid state advantages of long life, high operating speed, low pick-up power, bounce free operation, low thermal voltages and miniaturization. These advantages allow product improvement and design innovations in many applications such as process control, multiplexing, telecommunications, automatic test equipment, and data acquisition.

The PVA30 Series can switch analog signals from thermocouple level to 300 volts peak AC or DC polarity. Signal frequencies into the RF range are easily controlled and switching rates up to 25 kHz are achievable.

The extremely small thermally generated offset voltages allow increased measurement accuracies. The critical output semiconductors are completely shielded from the infra-red radiation of the input LED. Therefore, photocurrents in the output BOSFET are nonexistent and there is not an output offset resulting from radiation from the input LED drive.

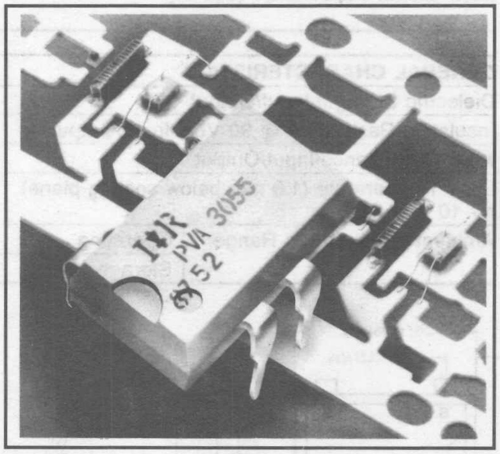
Unique silicon technology developed by International Rectifier forms the heart of the PVA. The monolithic BOSFET contains a bidirectional N channel power MOSFET output structure. In addition, this power IC chip has input circuitry for fast turn-off and gate protection functions. This section of the BOSFET chip utilizes both bipolar and MOS technology to form NPN transistors, P channel MOSFETs, resistors, diodes and capacitors.

The photovoltaic generator similarly utilizes a unique International Rectifier alloyed multijunction structure. The excellent current conversion efficiency of this technique results in the very fast response of the PVA microelectronic power IC relay.

This advanced semiconductor technology has created a radically new control device. Designers can now develop switching systems to new standards of electrical performance and mechanical compactness.

(Bosfet is a trademark of International Rectifier)

- BOSFET Power IC ■
- 10^{10} Operations ■
- 25μ Sec Operating Time ■
- Low Output Capacitance ■
- 0.2μVolt Thermal Offset ■
- Offset independent of input drive ■
- 3 milliwatts Pick-Up Power ■
- 1000V/μsec dv/dt ■
- Bounce Free ■
- 8 Pin DIP Package ■
- −40°C to 85°C ■



Part Identification

Part No.	Operating Voltage AC/DC	Sensivity	Off-State Resistance
PVA3054	0-300V	5 mA	10^{10}ohms
PVA3055			10^{11}ohms

D

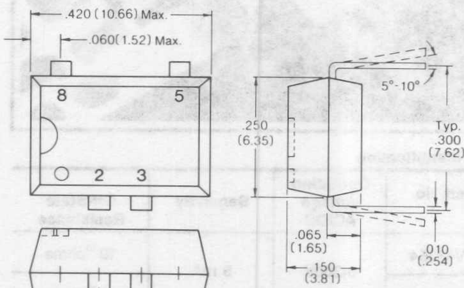
BOSFET PVA30 PhotoVoltaic Relay

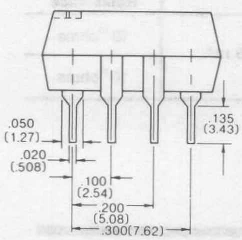
ELECTRICAL SPECIFICATIONS (−40°C ≤ T_A ≤ 85°C unless otherwise specified)

INPUT CHARACTERISTICS	PART NUMBERS PVA3054	PVA3055	UNITS
Min. Control Current: (See Fig. 1)			(DC)
For 40 mA Continuous Load Current.	5.0		mA @ 40ºC
For 22 mA Continuous Load Current.	5.0		mA @ 60ºC
Max. Control Current for Off-State Resistance at 25°C	10		µA (DC)
Control Current Range (Caution: Current limit input LED. (See Fig. 6)	2.0 to 25		mA (DC)
Max. Reverse Voltage	7.0		V (DC)

OUTPUT CHARACTERISTICS	PVA3054	PVA3055	
Operating Voltage Range	0±300		V (peak)
Max. Load Current 40°C (See Fig. 1)	40		mA (DC)
Response Time @ 25°C (See Fig. 7 and 8)			
Max. T (on) @ 12 mA Control, 20 mA Load, 100 VDC	25		µs
Max T. (off) @ 12 mA Control, 20 mA Load, 100 VDC	15		µs
Max. On-State Resistance at 25ºC (pulsed) (See Fig. 4) (10 mA Load 5 mA Control)	160		Ohms
Min. Off-State Resistance at 25°C @ 240 VDC	10^{10}	10^{11}	Ohms
Max. Off-State Leakage at 25°C @ 5.0 VDC (See fig. 5)	–	0.05	nA
Max. Thermal Offset Voltage @ 5.0 mA Control $V_{O\ (OS)}$	0.2		µ volts
Min. Off-State dv/dt	1000		V/µs
Max. Output Capacitance (See Fig. 9)	3.0		pF @ 40 VDC

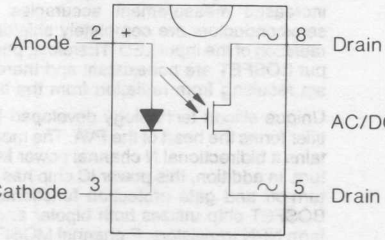
GENERAL CHARACTERISTICS		ALL MODELS	
Dielectric Strength-Input/Output		2500	V (RMS)
Insulation Resistance @ 90 VDC-Input/Output		10^{12} @ 25°C – 50% RH	Ohms
Max. Capacitance-Input/Output		1.0	pf
Lead Temperature (1.6 mm below seating plane) for 10 seconds		260	°C
Ambient Temperature Range:	Operating	−40 to 85	°C
	Storage	-40 to 100	°C



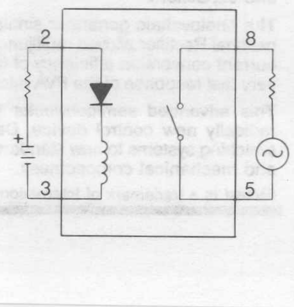


Mechanical Specifications
Dimensions: Inches (mm)
Package Size: 8 Pin DIP
Tolerances: .015 (.38) unless otherwise specified
Case Material: Molded epoxy
Weight: .07 oz. (2 grams)

Wiring Diagram



Electromechanical Analogy



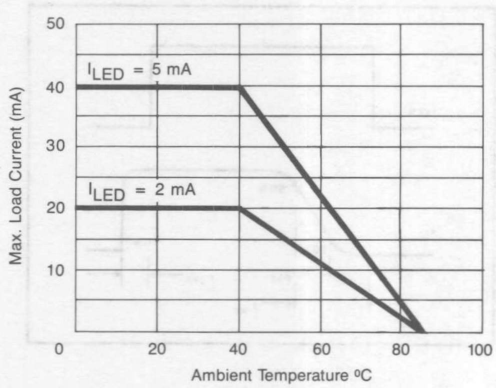


Figure 1. Current Derating Curves

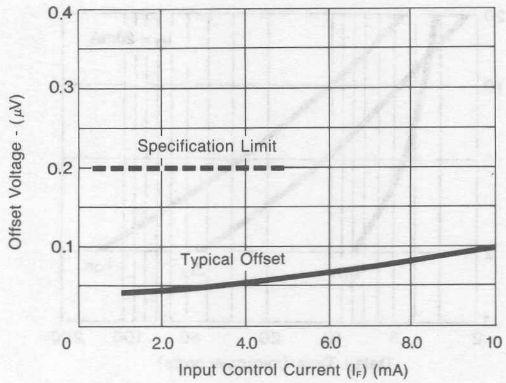


Figure 2. Offset Voltage

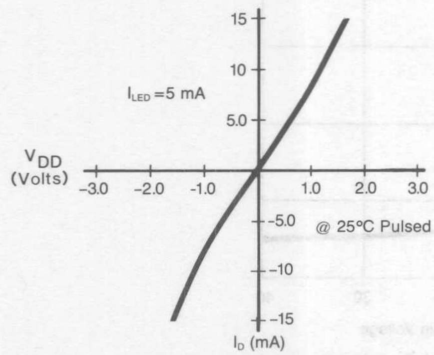


Figure 3. Typical On Characteristic

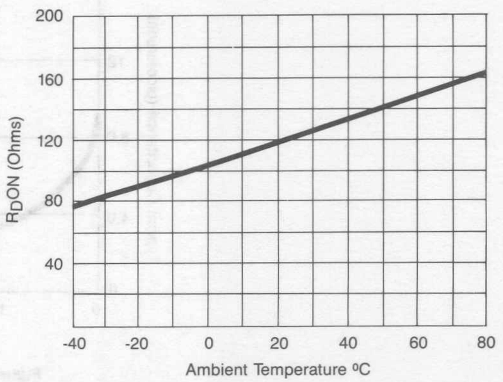


Figure 4. Typical On Resistance

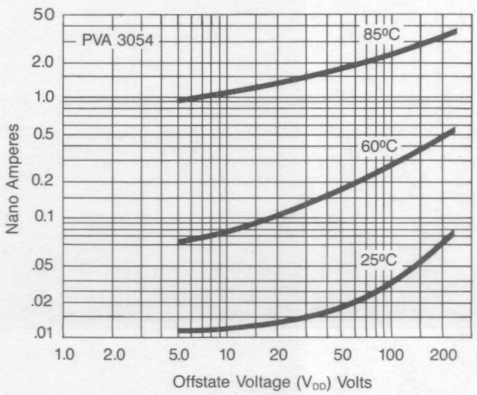


Figure 5. Typical Variation of Offstate Leakage Current

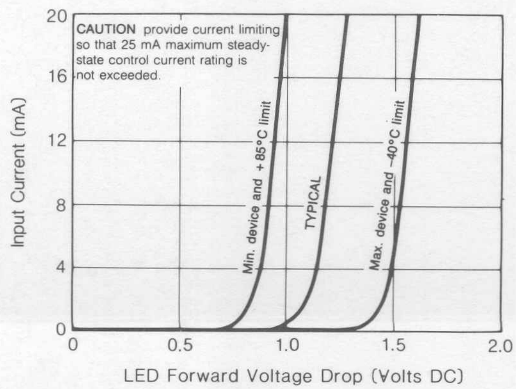


Figure 6. Input Characteristics (Current Controlled)

D

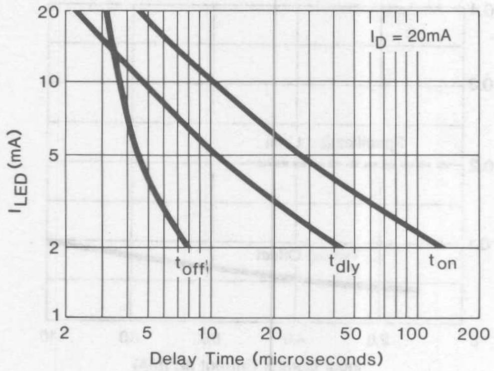


Figure 7. Typical Delay Times

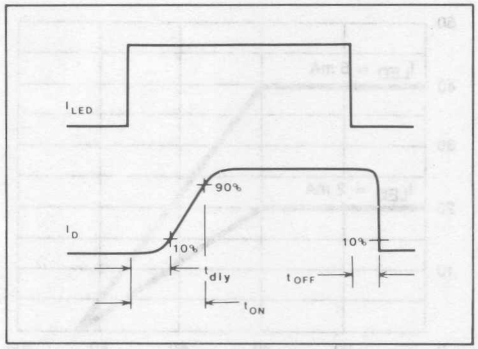


Figure 8. Delay Time Definitions

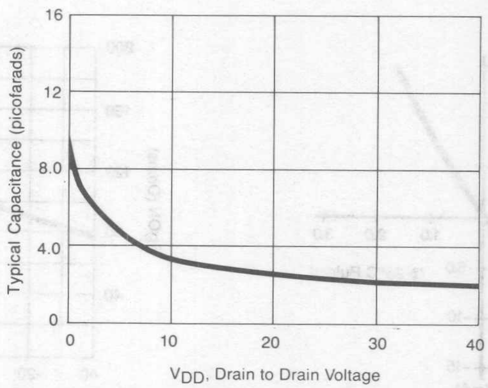


Figure 9. Typical Output Capacitance

Data Sheet No. PD-1.021B

INTERNATIONAL RECTIFIER IOR

SERIES PVA33

Microelectronic Power IC Relay

Single Pole, 130 mA
0-300V AC/DC

BOSFET® PhotoVoltaic Relay

GENERAL DESCRIPTION

The Photovoltaic AC Relay (PVA) is a single-pole, normally open solid state replacement for electro-mechanical relays used for general purpose switching of analog signals. It utilizes as an output switch a unique bidirectional (AC or DC) MOSFET power IC termed a BOSFET. The BOSFET is controlled by a photovoltaic generator of novel construction, which is energized by radiation from a dielectrically isolated light emitting diode (LED).

PVA FEATURES

The PVA overcomes the limitations of both conventional and reed electromechanical relays by offering the solid state advantages of long life, high operating speed, low pick-up power, bounce free operation, low thermal voltages and miniaturization. These advantages allow product improvement and design innovations in many applications such as process control, multiplexing, telecommunications, automatic test equipment, and data acquisition.

The PVA can switch analog signals from thermocouple level to 300 volts peak AC or DC polarity. Signal frequencies into the RF range are easily controlled and switching rates up to 5 kHz are achievable. The extremely small thermally generated offset voltages allow increased measurement accuracies.

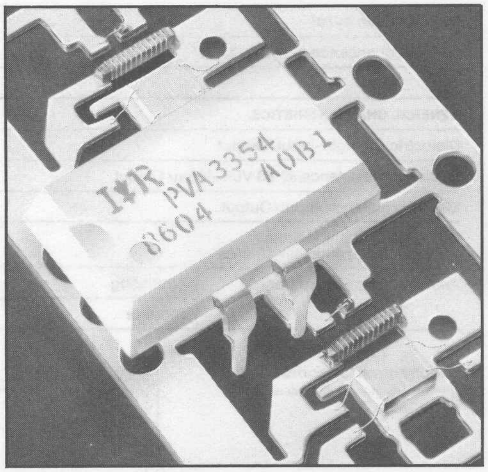
Unique silicon technology developed by International Rectifier forms the heart of the PVA. The monolithic BOSFET contains a bidirectional N channel power MOSFET output structure. In addition, this power IC chip has input circuitry for fast turn-off and gate protection functions. This section of the BOSFET chip utilizes both bipolar and MOS technology to form NPN transistors, P channel MOSFETs, resistors, diodes and capacitors.

The photovoltaic generator similarly utilizes a unique International Rectifier alloyed multi-junction structure. The excellent current conversion efficiency of this technique results in the very fast response of the PVA microelectronic power IC relay.

This advanced semiconductor technology has created a radically new control device. Designers can now develop switching systems to new standards of electrical performance and mechanical compactness.

(BOSFET is a trademark of International Rectifier)

- **BOSFET Power IC**
- **10^{10} Operations**
- **100 μSec Operating Time**
- **0.2 μVolt Thermal Offset**
- **3 milliwatts Pick-Up Power**
- **1000 V/μsec dv/dt**
- **Bounce Free**
- **8-Pin DIP Package**
- **-40° C to 85° C**
- **UL Recognized - File E88583**



Part Identification

Part No.	Operating Voltage AC/DC	Sensitivity	Off-State Resistance
PVA2352	0-200V	5 mA	10^8 Ohms
PVA3324	0-300V	2 mA	10^{10} Ohms
PVA3354		5 mA	10^{10} Ohms

D

BOSFET PVA33 PhotoVoltaic Relay

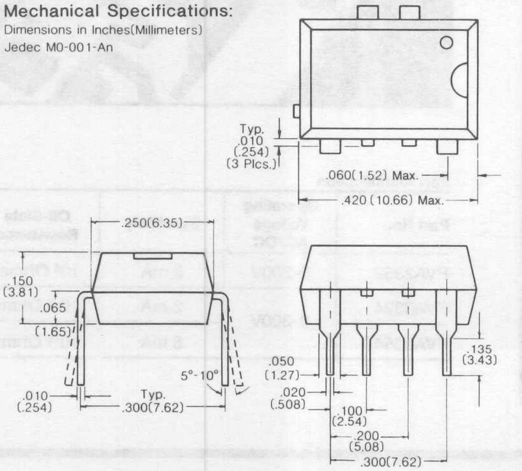
ELECTRICAL SPECIFICATIONS (–40°C ≤ T_A ≤ 85°C unless otherwise specified)

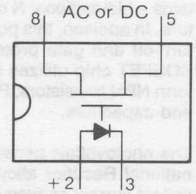
INPUT CHARACTERISTICS	PART NUMBERS			UNITS
	PVA2352	PVA3324	PVA3354	
Min. Control Current: (See Figs. 1 & 2)				(DC)
For 20 mA Continuous Load Current.	2.0	1.0	2.0	mA @ 25°C
For 100 mA Continuous Load Current.	5.0	2.0	5.0	mA @ 25°C
For 10 mA Continuous Load Current.	5.0	2.0	5.0	mA @ 85°C
Max. Control Current for Off-State Resistance at 25°C		10		μA (DC)
Control Current Range (Caution: Current limit input LED. See Fig. 6)		2.0 to 25		mA (DC)
Max Reverse Voltage		7.0		V (DC)
Response Time (See Fig. 7 and 8)				
Max. $T_{(on)}$ @ 12 mA Control, 50 mA load, 100 VDC, 25°C, 0 to 90%		100		microsec
Max. $T_{(off)}$ @12mA control, 50 mA load, 100 VDC, 25°C, 100% to 10%		50		microsec

OUTPUT CHARACTERISTICS	PVA2352	PVA3324	PVA3354	
Operating Voltage Range	0 ± 200		0 ± 300	V (peak)
Max. Load Current 40°C (See Fig. 1 and 2)		130		mA (DC)
Max. On-State Resistance 25°C (pulsed) (See Fig. 4) (50mA Load 5mA Control)		24		Ohms
Min. Off-State Resistance at 25°C (See Fig. 5)	10^8 @ 160VDC	10^{10} @ 240 VDC		Ohms
Max. Thermal Offset Voltage, @ 5.0 mA Control		0.2		μ volts
Min. Off-State dv/dt		1000		V/μs
Output Capacitance (See Fig. 10)		12		pf @ 50 VDC

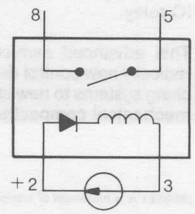
GENERAL CHARACTERISTICS		ALL MODELS	
Dielectric Strength-Input/Output		2500	V (RMS)
Insulation Resistance @ 90 VDC-Input/Output		10^{12} @ 25°C – 50% RH	Ohms
Max. Capacitance-Input/Output		1.0	pf
Lead Temperature (1.6mm below seating plane) for 10 secs.		260	°C
Ambient Temperature Range:	Operating	–40 to 85	°C
	Storage	–40 to 100	°C

Mechanical Specifications:
Dimensions in Inches(Millimeters)
Jedec M0-001-An





Wiring Diagram



Electromechanical Analogy

2mA To Operate

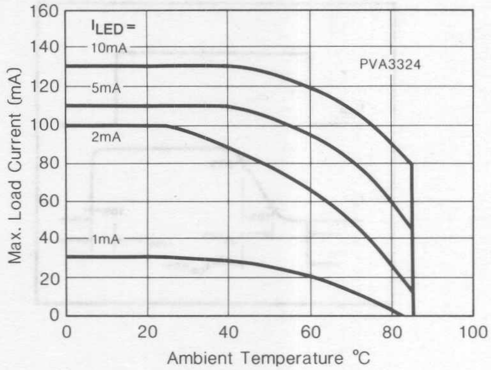


Figure 1. Current Derating Curves

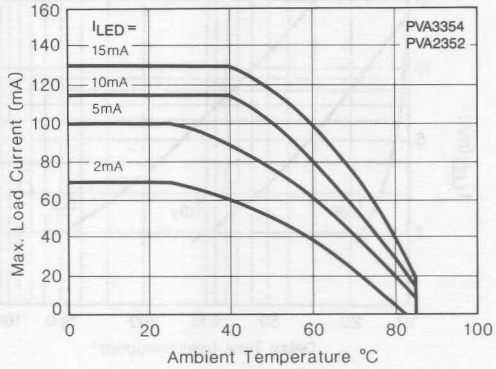


Figure 2. Current Derating Curves

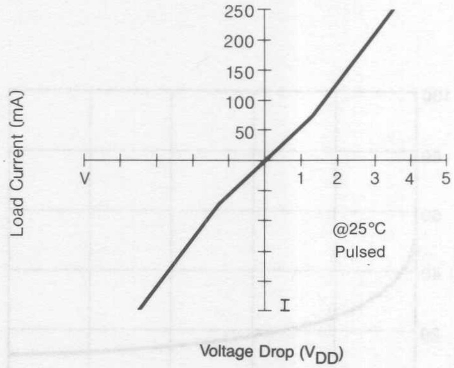


Figure 3. Linearity Characteristic

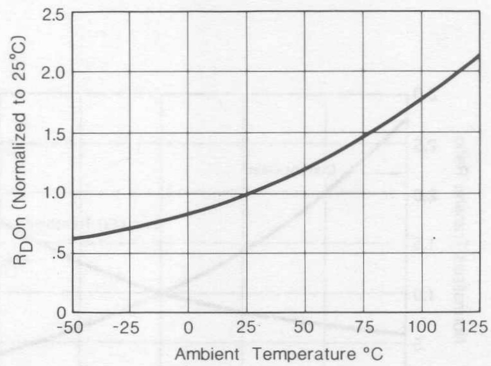


Figure 4. Typical Normalized On-Resistance

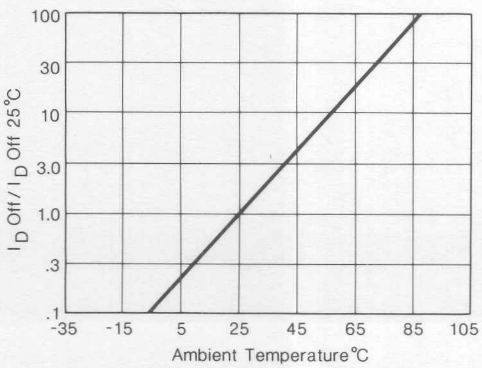


Figure 5. Normalized Off-State Leakage

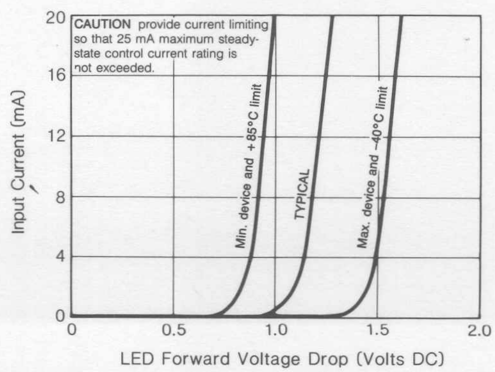


Figure 6. Input Characteristics (Current Controlled)

D

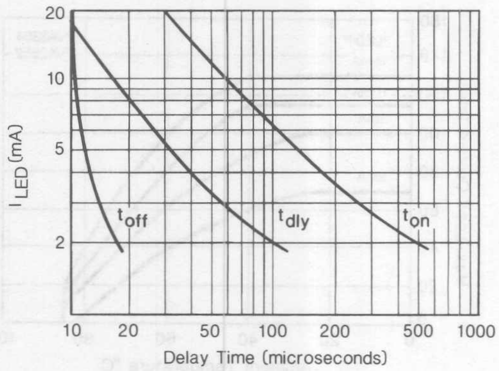


Figure 7. Typical Delay Times

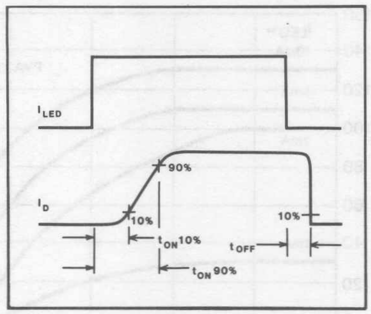


Figure 8. Delay Time

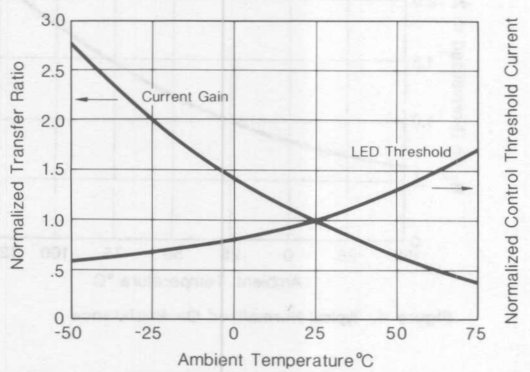


Figure 9. Typical Control Threshold and Transfer Ratio

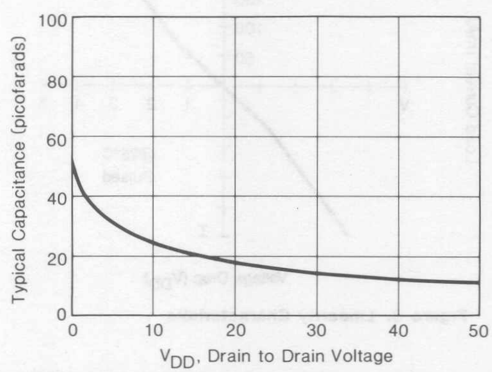


Figure 10. Typical Output Capacitance

Data Sheet No. PD-1.022B

INTERNATIONAL RECTIFIER IOR

SERIES PVAZ1

Microelectronic Power IC Relay

Single Pole, 1.0A
0-60V AC/DC

MOSFET PhotoVoltaic Relay

- 10^{10} Operations
- 500 μSec Turn-On Time
- 0.5 Ohm On-Resistance
- 0.2 μVolt Thermal Offset
- 10 milliwatts Pick-Up Power
- 1000 V/μSec dv/dt
- Bounce Free
- 8-Pin DIP Package
- -40°C to 85°C

GENERAL DESCRIPTION

The Photovoltaic Relay PVAZ172 is a single-pole, normally open (Form 1A) solid state replacement for low current electromechanical relays. It will control power loads up to ±60 volts peak (bidirectional or DC) at currents up to 1.0 amperes. The solid state output section consists of two N channel HEXFET® power MOSFETs in inverse series connection to provide bidirectional operation. The HEXFET output stage is actuated by a multicell photovoltaic generator of novel construction. Input isolation is provided by a light emitting diode (LED) whose radiation is coupled through a solid, transparent dielectric to energize the photovoltaic generator.

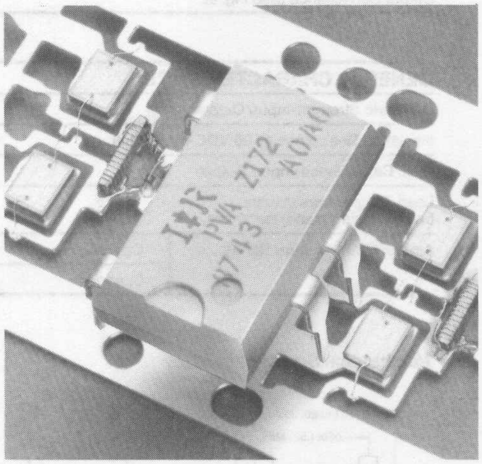
PVAZ172 FEATURES

The PVAZ172 overcomes the limitations of both conventional and reed electromechanical relays by offering the solid state advantages of long life, high operating speed, low pick-up power, bounce free operation, low thermal voltages and miniaturization. Operating life up to 10^{10} operations is achieved with direct logic level signal compatibility in a package volume of less than 0.016 cubic inches. Relays may be paralleled for lower on-resistance and higher current capability.

The HEXFETs used in the output have widespread recognition as the leading power MOSFET design and the most reliable power transistor ever produced. The photovoltaic generator in this relay similarly uses a unique International Rectifier alloyed multi-junction structure. The excellent current conversion efficiency of this technique results in the high sensitivity and high speed of this microelectronic power IC relay.

This advanced semiconductor technology has created a radically new control device. Designers of process control, interface modules, telecommunications systems and automatic test equipment can now develop switching systems to new standards of electrical performance and mechanical compactness.

(HEXFET is a trademark of International Rectifier)



Part Identification

Part No.	Operating Voltage AC/DC	Sensitivity	Off. State Resistance
PVAZ172	0-60	10mA	10^8 Ohms

D

PVAZ1 PhotoVoltaic Relay

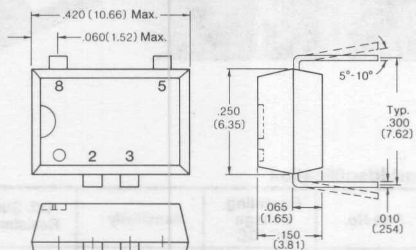
ELECTRICAL SPECIFICATIONS (-40°C ≤ TA 85°C unless otherwise specified)

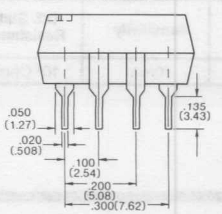
INPUT CHARACTERISTICS	PART NUMBERS PVAZ172	UNITS
Min. Control Current: (See Figs. 1 & 2) For 1.0 A Continuous Load Current For 1.0 A Continuous Load Current For 0.3 A Continuous Load Current	 10 20 10	(DC) mA @ 25°C mA @ 40°C mA @ 85°C
Max. Control Current for Off-State Resistance at 25°C	10	μA (DC)
Control Current Range (Caution: Current limit input LED. See Fig. 6)	4.0 to 25	mA (DC)
Max Reverse Voltage	7.0	V (DC)

OUTPUT CHARACTERISTICS		UNITS
Operating Voltage Range	0 ± 60	V (peak)
Max. Load Current 40°C (See Fig. 1 and 2)	1.0	A (DC)
Response Time @ 25°C (See Fig. 7 and 8) Max. $T_{(on)}$ @ 12 mA Control, 500 mA load, 50 VDC,	0.5	millisec
Max. $T_{(off)}$ @ 12mA control, 500 mA load, 50 VDC	10	millisec
Max. On-State Resistance 25°C (pulsed) (See Fig. 4) 1.0A Load 10mA Control	0.5	Ohms
Min. Off-State Resistance at 25°C @ 48 VDC (See Fig. 5)	10^8	Ohms
Max. Thermal Offset Voltage, @ 5.0 mA Control	0.2	μ volts
Min. Off-State dv/dt	1000	V/μs
Output Capacitance (See Fig. 9)	120	pF @ 50 VDC

GENERAL CHARACTERISTICS			UNITS
Dielectric Strength-Input/Output		1500	V (RMS)
Insulation Resistance @ 90 VDC-Input/Output		10^{12} @ 25°C – 50% RH	Ohms
Max. Capacitance-Input/Output		1.0	pF
Lead Temperature (1.6mm below seating plane) for 10 sec.		260	°C
Ambient Temperature Range:	Operating	-40 to 85	°C
	Storage	-40 to 100	°C

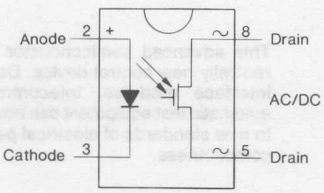
Mechanical Specifications:



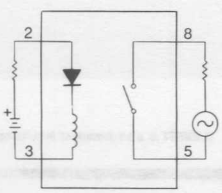


Dimensions: Inches (mm)
Package Size: 8 Pin DIP
Tolerances: .015 (.38) unless otherwise specified
Case Material: Molded epoxy
Weight: .07 oz. (2 grams)

Wiring Diagrams:



Schematic



Electromechanical Analogy

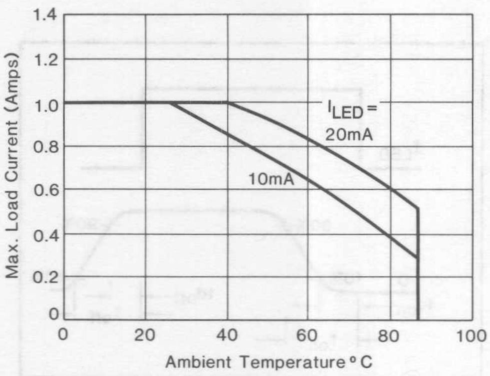


Figure 1. Current Derating Curves

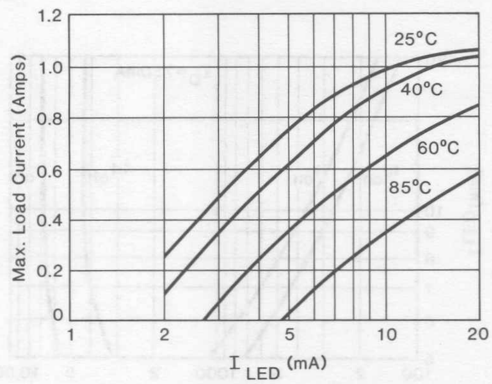


Figure 2. Typical Control Current Requirements

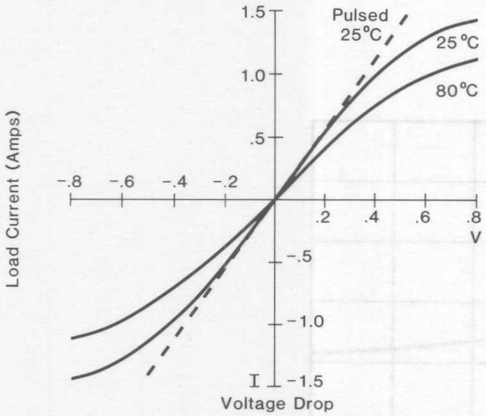


Figure 3. Linearity Characteristic

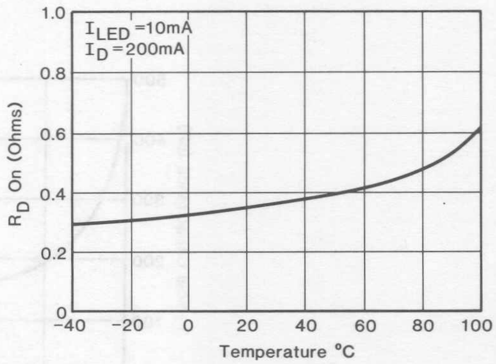


Figure 4. Typical On-Resistance

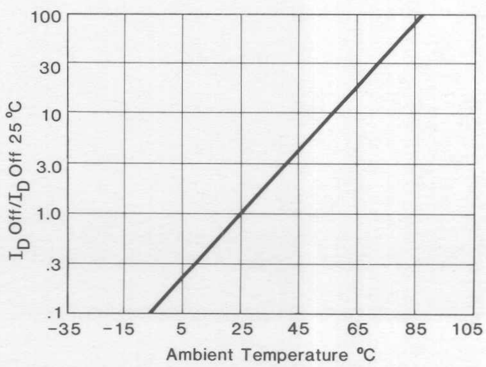


Figure 5. Normalized Off-State Leakage

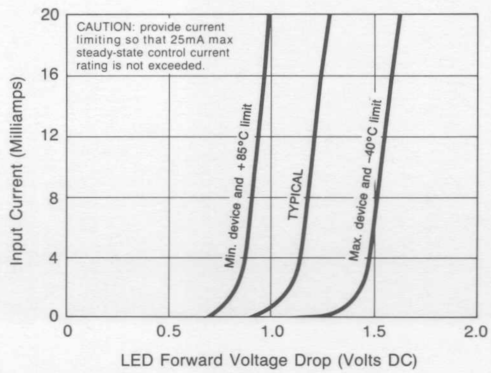


Figure 6. Input Characteristics (Current Controlled)

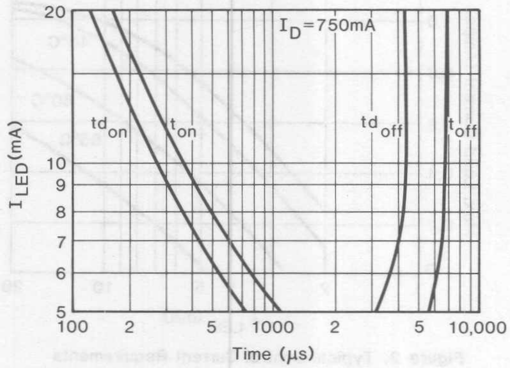


Figure 7. Typical Delay Times

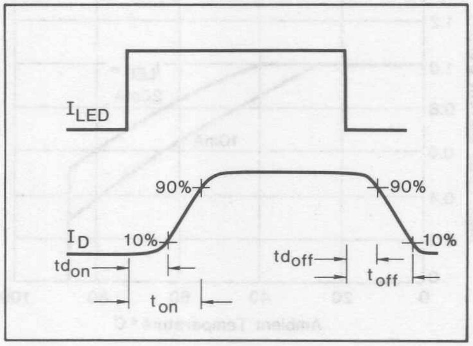


Figure 8. Delay Time Definitions

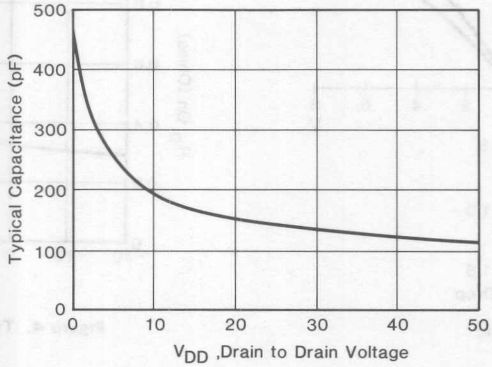


Figure 9. Typical Output Capacitance

INTERNATIONAL RECTIFIER IOR

SERIES PVD10

Microelectronic
Power IC Relay

Single Pole, 160 mA
0-100V DC

BOSFET® PhotoVoltaic Relay

GENERAL DESCRIPTION

The Photovoltaic DC Relay (PVD) is a single-pole, normally open solid state replacement for electromechanical relays used for general purpose switching of analog signals. It utilizes as an output switch a unique bidirectional (AC or DC) MOSFET power IC termed a BOSFET. The BOSFET is controlled by a photovoltaic generator of novel construction, which is energized by radiation from a dielectrically isolated light emitting diode (LED).

PVD FEATURES

The PVD overcomes the limitations of both conventional and reed electromechanical relays by offering the solid state advantages of long life, high operating speed, low pick-up power, bounce free operation, low thermal voltages and miniaturization. These advantages allow product improvement and design innovations in many applications such as process control, multiplexing, telecommunications, automatic test equipment, and data acquisition.

The PVD can switch analog signals from thermocouple level to 100 volts peak DC. Signal frequencies into the RF range are easily controlled and switching rates up to 18 kHz are achievable. The extremely small thermally generated offset voltages allow increased measurement accuracies.

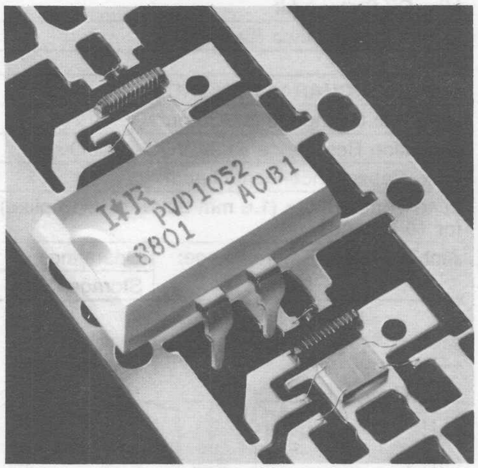
Unique silicon technology developed by International Rectifier forms the heart of the PVD. The monolithic BOSFET contains a bidirectional N channel power MOSFET output structure. In addition, this power IC chip has input circuitry for fast turn-off and gate protection functions. This section of the BOSFET chip utilizes both bipolar and MOS technology to form NPN transistors, P channel MOSFETs, resistors, diodes and capacitors.

The photovoltaic generator similarly utilizes a unique International Rectifier alloyed multi-junction structure. The excellent current conversion efficiency of this technique results in the very fast response of the PVD microelectronic power IC relay.

This advanced semiconductor technology has created a radically new control device. Designers can now develop switching systems to new standards of electrical performance and mechanical compactness.

(BOSFET is a trademark of International Rectifier)

- BOSFET Power IC
- 10^{10} Operations
- 25 μSec Operation Time
- 3 milliwatts Pick-Up Power
- 1000 V/μsec dv/dt
- Bounce Free
- 8-Pin DIP Package
- −40°C to 85°C



Part Identification

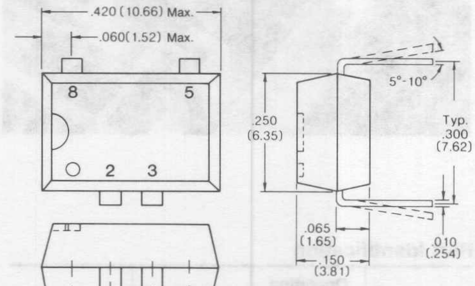
Part No.	Operating Voltage DC	Sensitivity	Off-State Resistance
PVD1052	0-100V	5 mA	10^8 Ohms
PVD1054			10^{10} Ohms

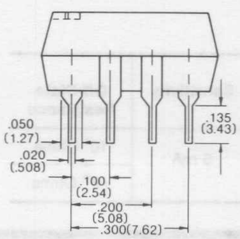
D

BOSFET PVD10 PhotoVoltaic Relay

ELECTRICAL SPECIFICATIONS (−40°C ≤ T_A ≤ 85°C unless otherwise specified)

INPUT CHARACTERISTICS	PART NUMBERS		UNITS
	PVD1052	PVD1054	
Min. Control Current: (See Figs. 1 & 2)			(DC)
For 80 mA Continuous Load Current.	2.0		mA @ 25°C
For 130 mA Continuous Load Current.	5.0		mA @ 40°C
For 50 mA Continuous Load Current.	5.0		mA @ 85°C
Max. Control Current for Off-State Resistance at 25°C	10		µA (DC)
Control Current Range (Caution: Current limit input LED. (See Fig. 6)	2.0 to 25		mA (DC)
Max. Reverse Voltage	7.0		V (DC)
OUTPUT CHARACTERISTICS			
Operating Voltage Range	0 to +100		V (peak)
Max. Load Current 40°C (See Fig. 1)	160		mA (DC)
Max. On-State Resistance 25°C (Pulsed) (See Fig. 4) (50 mA Load 5 mA Control)	8.0		Ohms
Min. Off-State Resistance at 25°C (See Fig. 5)	10^8 @ 80 VDC	10^{10} @ 80 VDC	Ohms
Response Time (See Fig. 7 and 8)			
Max. $T_{(on)}$ 12 mA Control, 50 mA Load, 50 VDC, 25°C, 0 to 90%	25		microsec
Max. $T_{(off)}$ @ 12 mA Control, 50 mA Load, 50 VDC, 25°C, 100% to 10% (See Fig. 7)	15		microsec
Max. Thermal Offset Voltage @ 5.0 mA Control	0.2		µ volts
Min. Off-State dv/dt	1000		V/µs
Output Capacitance (See Fig. 9)	8.0		pf @ 50 VDC
GENERAL CHARACTERISTICS	**ALL MODELS**		
Dielectric Strength-Input/Output	2500		V (RMS)
Insulation Resistance @ 90 VDC-Input/Output	10^{12} @ 25°C - 50% RH		Ohms
Max. Capacitance-Input/Output	1.0		pf
Lead Temperature (1.6 mm below seating plain) for 10 seconds	260		°C
Ambient Temperature Range: Operating	−40 to 85		°C
Ambient Temperature Range: Storage	−40 to 100		°C

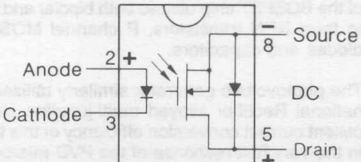




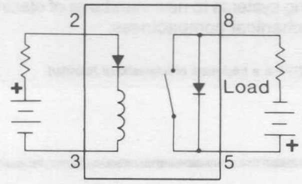
Mechanical Specifications
Dimensions: Inches (mm)
Package Size: 8 Pin DIP
Tolerances: .015 (.38) unless otherwise specified
Case Material: Molded epoxy
Weight: .07 oz. (2 grams)

Wiring Diagrams

Schematic



Electromechanical Analogy



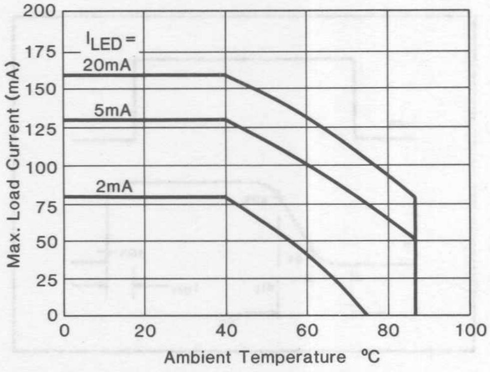


Figure 1. Current Derating Curves

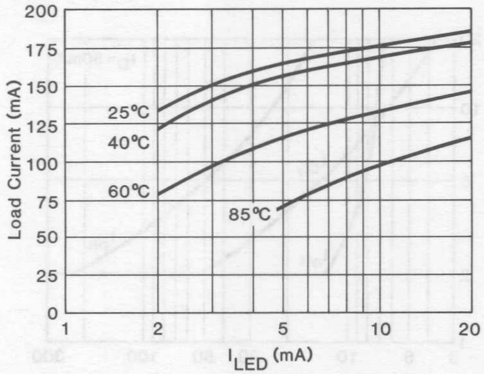


Figure 2. Typical Control Current Requirements

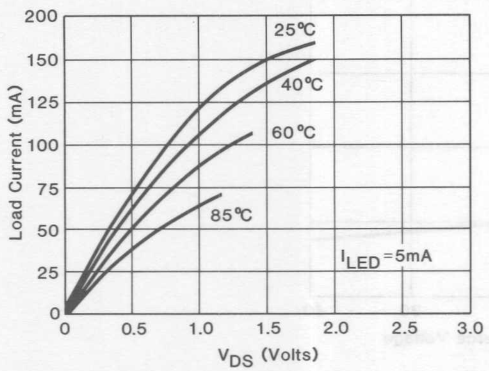


Figure 3. Typical On Characteristics

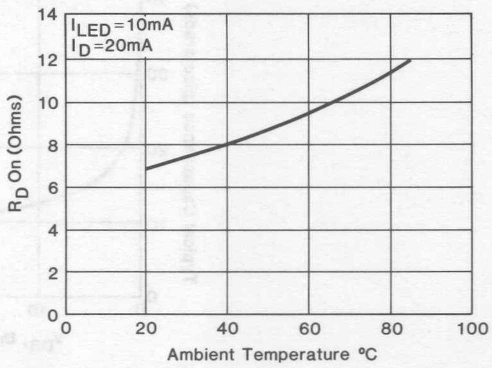


Figure 4. Typical On-Resistance

D

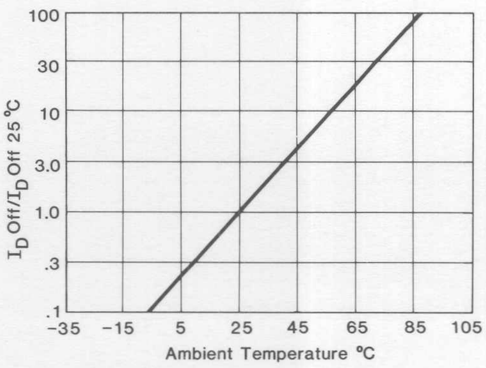


Figure 5. Normalized Off-State Leakage

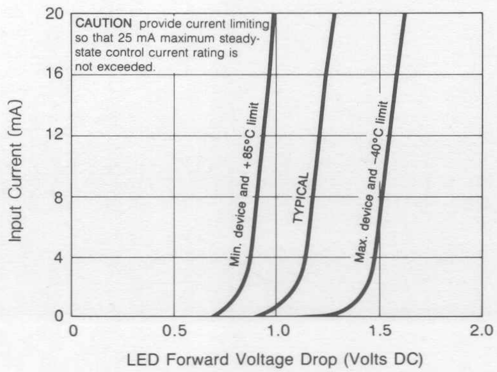


Figure 6. Input Characteristics (Current Controlled)

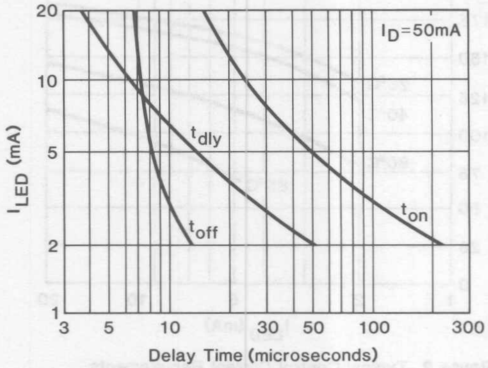


Figure 7. Typical Delay Times

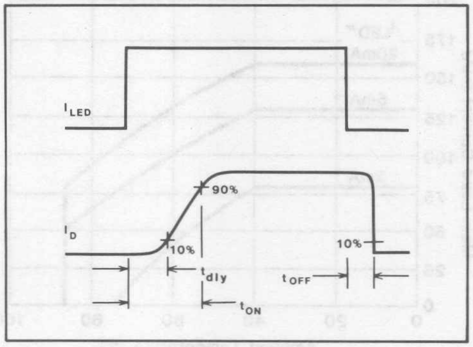


Figure 8. Delay Time Definitions

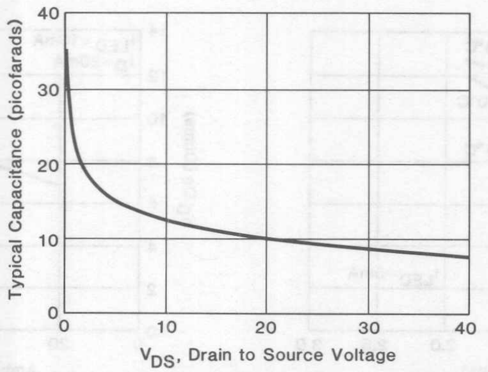


Figure 9. Typical Output Capacitance

INTERNATIONAL RECTIFIER IOR

SERIES PVD13

Microelectronic Power IC Relay

Single Pole, 500 mA
0-100V DC

BOSFET® PhotoVoltaic Relay

GENERAL DESCRIPTION

The Photovoltaic DC Relay (PVD) is a single-pole, normally open solid state replacement for electromechanical relays used for general purpose switching of analog signals. It utilizes as an output switch a unique bidirectional (AC or DC) MOSFET power IC termed a BOSFET. The BOSFET is controlled by a photovoltaic generator of novel construction, which is energized by radiation from a dielectrically isolated light emitting diode (LED).

PVD FEATURES

The PVD overcomes the limitations of both conventional and reed electromechanical relays by offering the solid state advantages of long life, high operating speed, low pick-up power, bounce free operation, low thermal voltages and miniaturization. These advantages allow product improvement and design innovations in many applications such as process control, multiplexing, telecommunications, automatic test equipment, and data acquisition.

The PVD can switch analog signals from thermocouple level to 100 volts peak DC. Signal frequencies into the RF range are easily controlled and switching rates up to 2 kHz are achievable. The extremely small thermally generated offset voltages allow increased measurement accuracies.

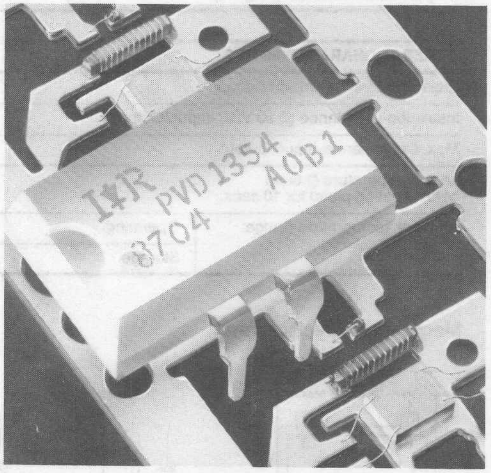
Unique silicon technology developed by International Rectifier forms the heart of the PVD. The monolithic BOSFET contains a bidirectional N channel power MOSFET output structure. In addition, this power IC chip has input circuitry for fast turn-off and gate protection functions. This section of the BOSFET chip utilizes both bipolar and MOS technology to form NPN transistors, P channel MOSFETs, resistors, diodes and capacitors.

The photovoltaic generator similarly utilizes a unique International Rectifier alloyed multi-junction structure. The excellent current conversion efficiency of this technique results in the very fast response of the PVD microelectronic power IC relay.

This advanced semiconductor technology has created a radically new control device. Designers can now develop switching systems to new standards of electrical performance and mechanical compactness.

(BOSFET is a trademark of International Rectifier)

- **BOSFET Power IC**
- **10^{10} Operations**
- **300 μSec Operating Time**
- **3 milliwatts Pick-Up Power**
- **1000 V/μsec dv/dt**
- **Bounce Free**
- **8-Pin DIP Package**
- **-40°C to 85°C**



D

Part Identification

Part No.	Operating Voltage DC	Sensitivity	Off-State Resistance
PVD1352	0-100V	5 mA	10^8 Ohms
PVD1354			10^{10} Ohms

BOSFET PVD13 PhotoVoltaic Relay

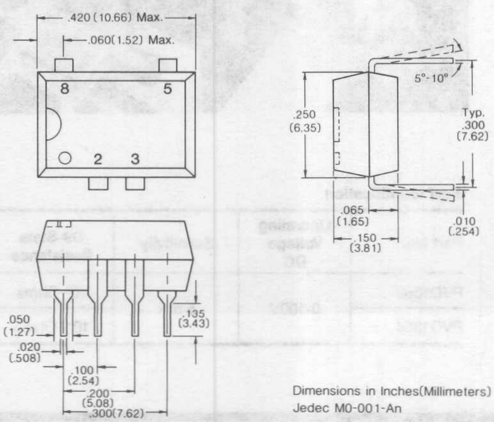
ELECTRICAL SPECIFICATIONS (–40°C ≤ T_A ≤ 85°C unless otherwise specified)

INPUT CHARACTERISTICS	PART NUMBERS		UNITS
	PVD1352	PVD1354	
Min. Control Current: (See Figs. 1 & 2) For 300 mA Continuous Load Current. For 400 mA Continuous Load Current. For 150 mA Continuous Load Current.	2.0 5.0 5.0		(DC) mA @ 25°C mA @ 40°C mA @ 85°C
Max. Control Current for Off-State Resistance at 25°C	10		μA (DC)
Control Current Range (Caution: Current limit input LED. See Fig. 6)	2.0 to 25		mA (DC)
Max. Reverse Voltage	7.0		V (DC)

OUTPUT CHARACTERISTICS	PVD1352	PVD1354	UNITS
Operating Voltage Range	0 to + 100		V (peak)
Max. Load Current 40°C (See Fig. 1)	500		mA (DC)
Max. On-State Resistance 25°C (Pulsed) (See Fig. 4) (200mA Load 5mA Control)	1.5		Ohms
Min. Off-State Resistance at 25°C (See Fig. 5)	10^8 @ 80 VDC	10^{10} @ 80 VDC	Ohms
Response Time (See Fig. 7 and 8)			
Max. $T_{(on)}$ 12 mA Control, 50 mA load, 100 VDC, 25°C, 0 to 90%	300		microsec
Max. $T_{(off)}$ @ 12 mA control, 50 mA load, 100 VDC, 25°C, 100% to 10% (See Fig. 8)	50		microsec
Max. Thermal Offset Voltage, @ 5.0 mA Control	0.2		μ volts
Min. Off-State dv/dt	1000		V/μs
Output Capacitance (See Fig. 10)	12		pf @ 50 VDC

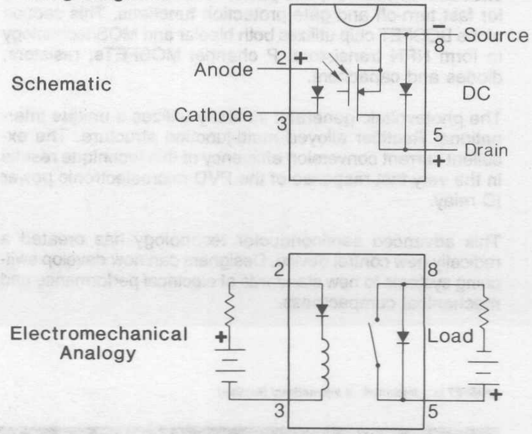
GENERAL CHARACTERISTICS		ALL MODELS	UNITS
Dielectric Strength-Input/Output		2500	V (RMS)
Insulation Resistance @ 90 VDC-Input/Output		10^{12} @ 25°C - 50% RH	Ohms
Max. Capacitance-Input/Output		1.0	pf
Lead Temperature (1.6mm below seating plain) for 10 secs.		260	°C
Ambient Temperature Range:	Operating	-40 to 85	°C
	Storage	-40 to 100	°C

Mechanical Specifications:



Dimensions in Inches(Millimeters)
Jedec M0-001-An

Wiring Diagrams



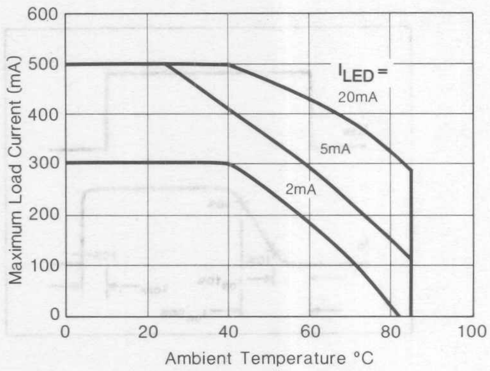


Figure 1. Current Derating Curves

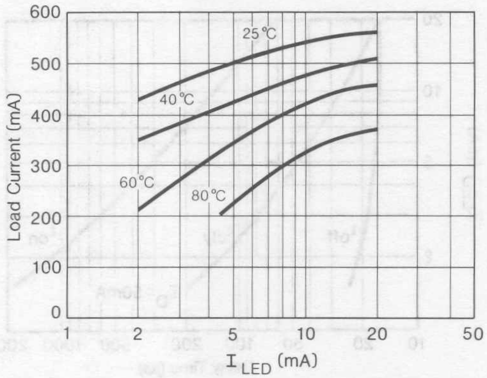


Figure 2. Typical Control Current Requirement

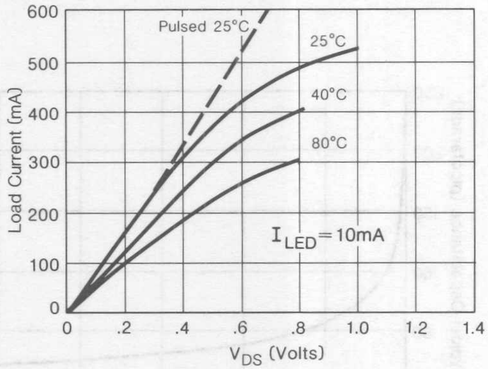


Figure 3. Typical On Characteristics

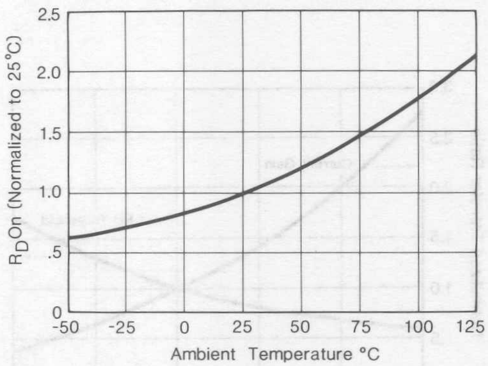


Figure 4. Typical Normalized On-Resistance

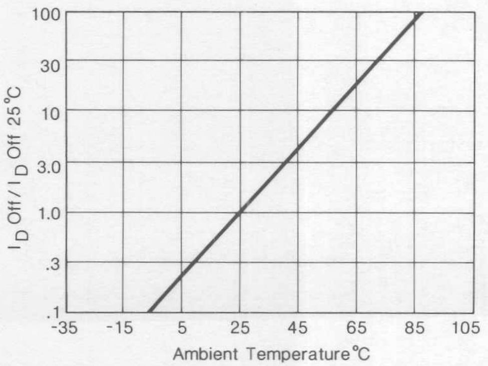


Figure 5. Normalized Off-State Leakage

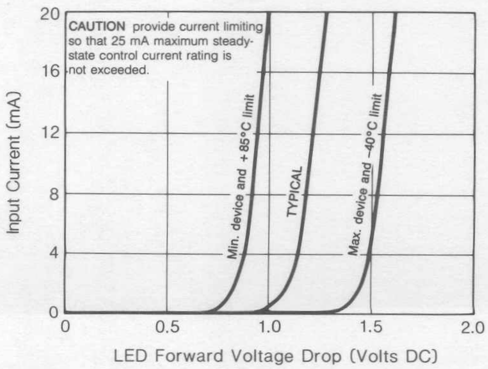


Figure 6. Input Characteristics (Current Controlled)

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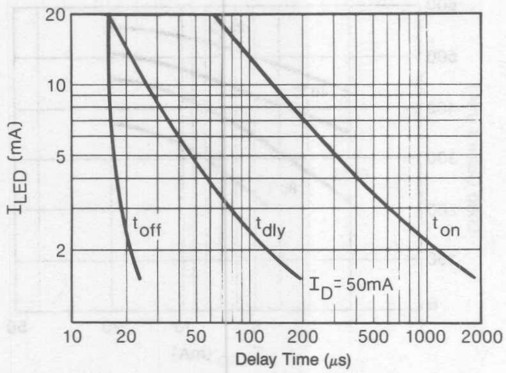


Figure 7. Typical Delay Times

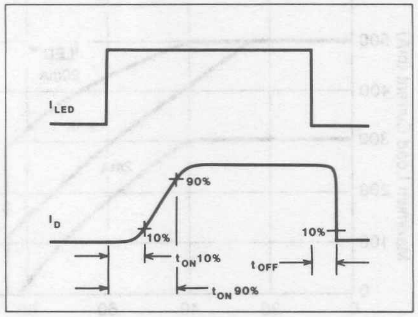


Figure 8. Delay Time Definitions

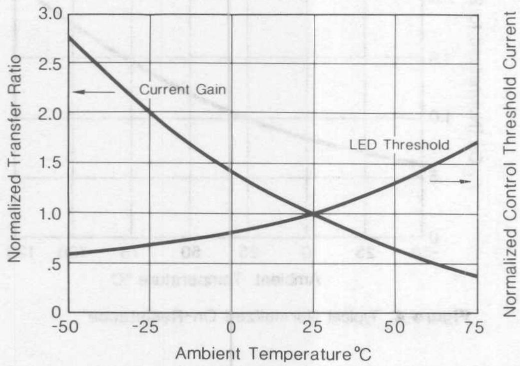


Figure 9. Typical Control Threshold and Transfer Ratio

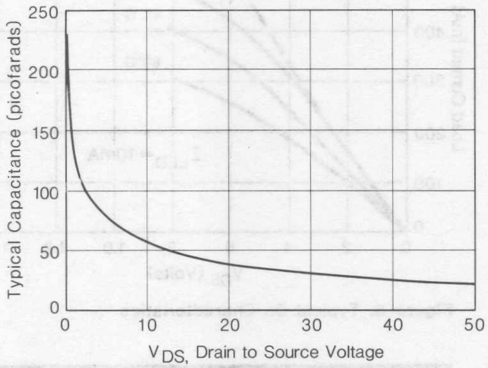


Figure 10. Typical Output Capacitance

Data Sheet No. PD-1.025B

INTERNATIONAL RECTIFIER IOR

SERIES PVD33

Microelectronic Power IC Relay

Single Pole, 220 mA
0-300V DC

BOSFET® PhotoVoltaic Relay

GENERAL DESCRIPTION

The Photovoltaic DC Relay (PVD) is a single-pole, normally open solid state replacement for electromechanical relays used for general purpose switching of analog signals. It utilizes as an output switch a unique bidirectional (AC or DC) MOSFET power IC termed a BOSFET. The BOSFET is controlled by a photovoltaic generator of novel construction, which is energized by radiation from a dielectrically isolated light emitting diode (LED).

PVD FEATURES

The PVD overcomes the limitations of both conventional and reed electromechanical relays by offering the solid state advantages of long life, high operating speed, low pick-up power, bounce free operation, low thermal voltages and miniaturization. These advantages allow product improvement and design innovations in many applications such as process control, multiplexing, telecommunications, automatic test equipment, and data acquisition.

The PVD can switch analog signals from thermocouple level to 100 volts peak DC. Signal frequencies into the RF range are easily controlled and switching rates up to kHz are achievable. The extremely small thermally generated offset voltages allow increased measurement accuracies.

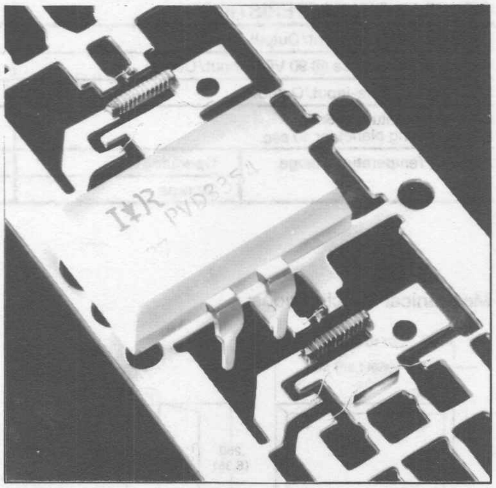
Unique silicon technology developed by International Rectifier forms the heart of the PVD. The monolithic BOSFET contains a bidirectional N channel power MOSFET output structure. In addition, this power IC chip has input circuitry for fast turn-off and gate protection functions. This section of the BOSFET chip utilizes both bipolar and MOS technology to form NPN transistors, P channel MOSFETs, resistors, diodes and capacitors.

The photovoltaic generator similarly utilizes a unique International Rectifier alloyed multi-junction structure. The excellent current conversion efficiency of this technique results in the very fast response of the PVD microelectronic power IC relay.

This advanced semiconductor technology has created a radically new control device. Designers can now develop switching systems to new standards of electrical performance and mechanical compactness.

(BOSFET is a trademark of International Rectifier)

- **BOSFET Power IC**
- **10^{10} Operations**
- **100 μSec Operating Time**
- **3 milliwatts Pick-Up Power**
- **1000 V/μsec dv/dt**
- **Bounce Free**
- **8-Pin DIP Package**
- **-40°C to 85°C**



D

Part Identification

Part No.	Operating Voltage DC	Sensitivity	Off-State Resistance
PVD2352	200	5 mA	10^8 Ohms
PVD3354	300		10^{10} Ohms

BOSFET PVD33 PhotoVoltaic Relay

IOR

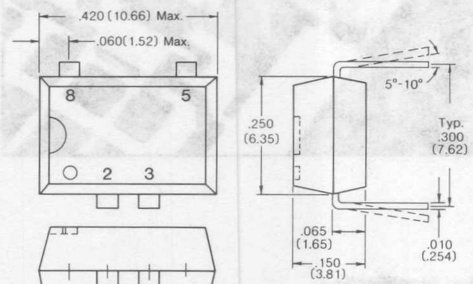
ELECTRICAL SPECIFICATIONS (–40°C ≤ T_A ≤ 85°C unless otherwise specified)

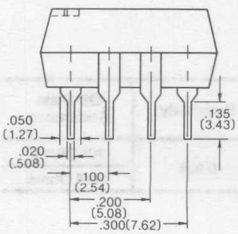
INPUT CHARACTERISTICS	PART NUMBERS		UNITS
	PVD2352	PVD3354	
Min. Control Current: (See Figs. 1 & 2) For 160mA Continuous Load Current. For 200mA Continuous Load Current. For 90 mA Continuous Load Current.	2.0 5.0 5.0		(DC) mA @ 25°C mA @ 40°C mA @ 85°C
Max. Control Current for Off-State Resistance at 25°C	10		μA (DC)
Control Current Range (Caution: Current limit input LED. See Fig. 6)	2.0 to 25		mA (DC)
Max. Reverse Voltage	7.0		V (DC)

OUTPUT CHARACTERISTICS	PVD2352	PVD3354	UNITS
Operating Voltage Range	200	300	V (peak)
Max. Load Current 40°C (See Fig. 1)	220		mA (DC)
Max. On-State Resistance 25°C (Pulsed) (See Fig. 4) (50mA Load 5mA Control)	6		Ohms
Min. Off-State Resistance at 25°C (See Fig. 5)	10^8 @ 160 VDC	10^{10} @ 240 VDC	Ohms
Response Time @ 25°C (See Fig. 7 and 8)			
Max. T(on) @ 12mA Control, 50 mA load, 100 VDC	100		μs
Max. T(off) @ 12mA Control, 50 mA load, 100 VDC	50		μs
Max. Thermal Offset Voltage, @ 5.0 mA Control	0.2		μ volts
Min. Off-State dv/dt	1000		V/μs
Output Capacitance (See Fig. 9)	20		pF @ 50 VDC

GENERAL CHARACTERISTICS		ALL MODELS	UNITS
Dielectric Strength-Input/Output		2500	V (RMS)
Insulation Resistance @ 90 VDC-Input/Output		10^{12} @ 25°C - 50% RH	Ohms
Max. Capacitance-Input/Output		1.0	pF
Lead Temperature (1.6mm below seating plane) for 10 sec.		260	°C
Ambient Temperature Range:	Operating	-40 to 85	°C
	Storage	-40 to 100	°C

Mechanical Specifications:

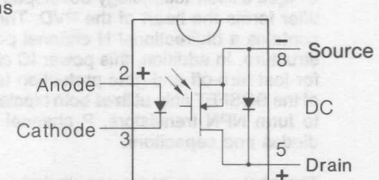




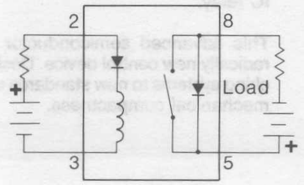
Dimensions: Inches (mm)
Package Size: 8 Pin DIP
Tolerances: .015 (.38) unless otherwise specified
Case Material: Molded epoxy
Weight: .07 oz. (2 grams)

Wiring Diagrams

Schematic



Electromechanical Analogy



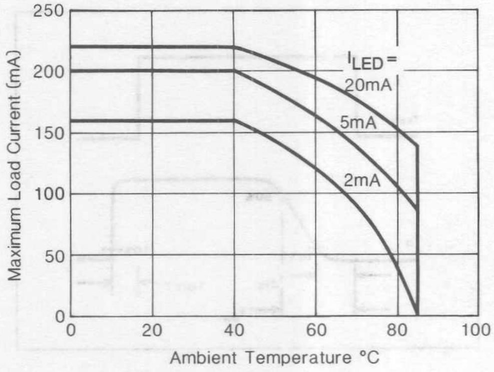


Figure 1. Current Derating Curves

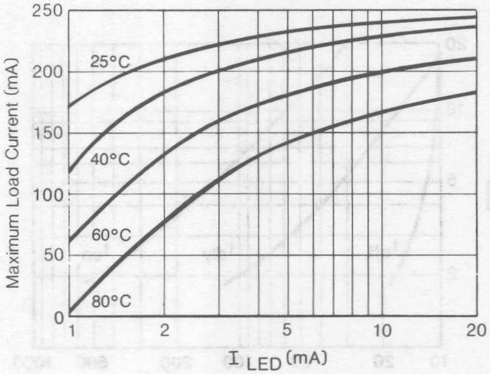


Figure 2. Typical Control Current Requirement

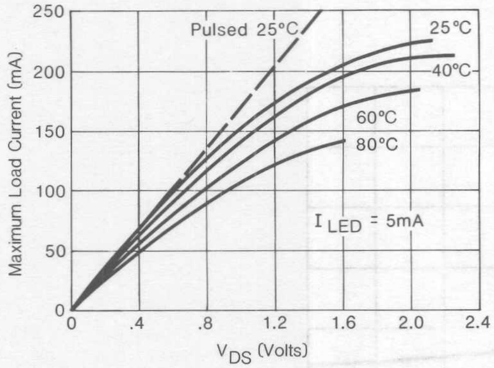


Figure 3. Typical On Characteristics

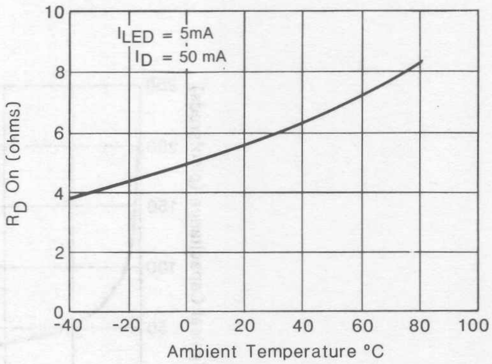


Figure 4. Typical On-Resistance

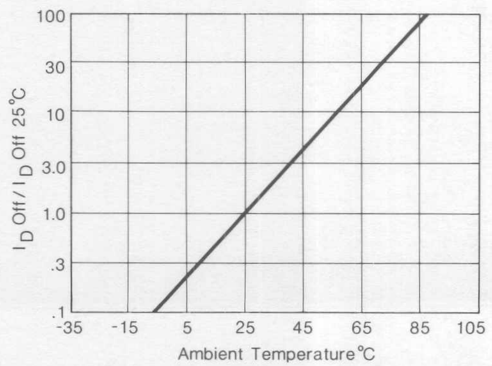


Figure 5. Normalized Off-State Leakage

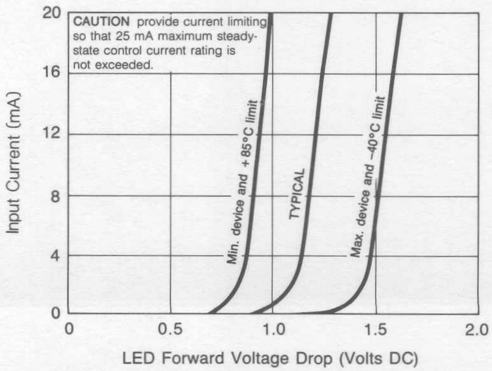


Figure 6. Input Characteristics (Current Controlled)

D

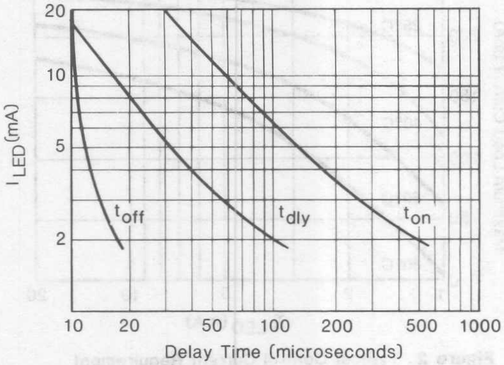


Figure 7. Typical Delay Times

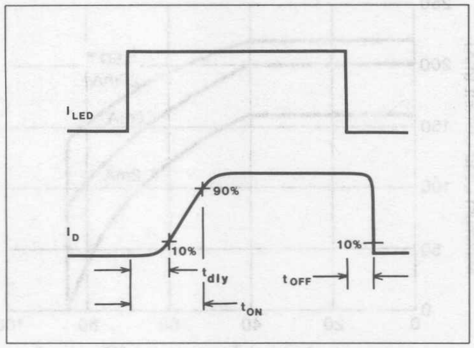


Figure 8. Delay Time Definitions

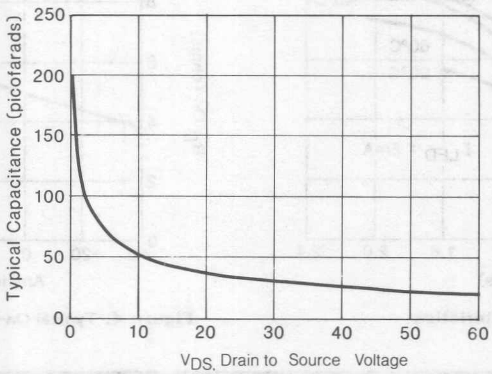


Figure 9. Typical Output Capacitance

Data Sheet No. PD-1.026B

INTERNATIONAL RECTIFIER IOR

SERIES PVDZ1

Microelectronic Power IC Relay

Single Pole, 1.4A
0-60V DC

MOSFET PhotoVoltaic Relay

GENERAL DESCRIPTION

The International Rectifier Photovoltaic DC Relay PVDZ172 is a single-pole, normally open solid state replacement for electromechanical relays used for general purpose switching to DC loads. It utilizes as an output switch a unique MOSFET power IC controlled by a photovoltaic generator of novel construction, which is energized by radiation from a dielectrically isolated light emitting diode (LED).

PVDZ172 FEATURES

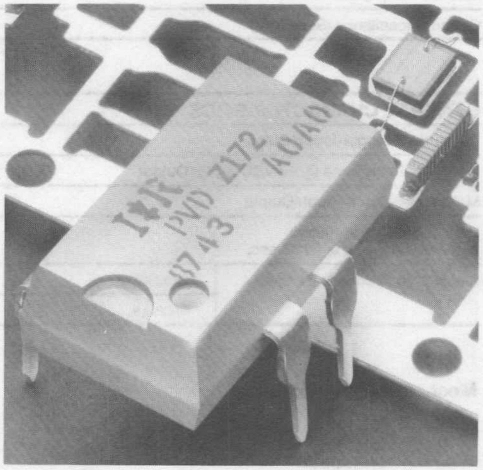
The PVDZ172 overcomes the limitations of both conventional and reed electromechanical relays by offering the solid state advantages of long life, high operating speed, low pick-up power, bounce free operation, low thermal voltages and miniaturization. These advantages allow product improvement and design innovations in many applications such as process control, multiplexing, telecommunications, automatic test equipment, and signal conditioning.

The PVDZ1 can switch analog signals from thermocouple level to 60 volts DC. Signal frequencies into the audio range are easily controlled and switching rates up to 100 Hz are achievable. The extremely small thermally generated offset voltages allow increased measurement accuracies.

Unique silicon technology developed by International Rectifier forms the heart of the PVDZ172. The photovoltaic generator similarly utilizes a unique International Rectifier alloyed multi-junction structure. The excellent current conversion efficiency of this technique results in the very fast response of the PVDZ1 microelectronic opwer IC relay.

This advanced semiconductor technology has created a radically new control device. Designers of process control, interface modules, telecommunications systems and automatic test equipment can now develop switching systems to new standards of electrical performance and mechanical compactness.

- 10^{10} Operations
- 500 μSec Turn-On Time
- 0.25 Ohm On-Resistance
- 100:1 Current Transfer Ratio
- 10 Milliwatts Pick-Up Power
- 1000 V/μSec dv/dt
- Bounce Free
- 8-Pin DIP Package
- -40°C to 85°C



D

Part Identification

Part No.	Operating Voltage DC	Sensitivity	Off. State Resistance
PVDZ172	0-60	10mA	10^8 Ohms

IOR

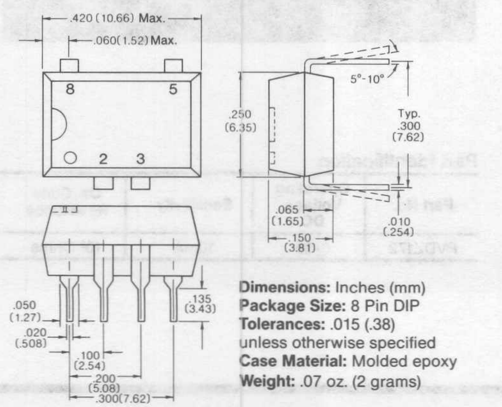
ELECTRICAL SPECIFICATIONS (-40°C ≤ TA 85°C unless otherwise specified)

INPUT CHARACTERISTICS	PART NUMBERS PVDZ172	UNITS
Min. Control Current: (See Figs. 1 & 2) For 1.4 A Continuous Load Current / For 0.6 A Continuous Load Current	20 / 10	(DC) mA @ 40°C / mA @ 85°C
Max. Control Current for Off-State Resistance at 25°C	10	μA (DC)
Control Current Range (Caution: Current limit input LED. See Fig. 6)	4.0 to 25	mA (DC)
Max Reverse Voltage	7.0	V (DC)

OUTPUT CHARACTERISTICS		UNITS
Operating Voltage Range	0 to 60	V (peak)
Max. Load Current 40°C (See Fig. 1 and 2)	1.4	A (DC)
Response Time @ 25°C (See Fig. 7 and 8) Max. $T_{(on)}$ @ 12 mA Control, 500 mA load, 50 VDC,	0.5	millisec
Max. $T_{(off)}$ @ 12mA control, 500 mA load, 50 VDC	8.0	millisec
Max. On-State Resistance 25°C (pulsed) (See Fig. 4) 1.0A Load 10mA Control	0.25	Ohms
Min. Off-State Resistance at 25°C @ 48 VDC (See Fig. 5)	10^8	Ohms
Max. Thermal Offset Voltage, @ 5.0 mA Control	0.2	μ volts
Min. Off-State dv/dt	1000	V/μs
Output Capacitance (See Fig. 9)	150	pF @ 50 VDC

GENERAL CHARACTERISTICS			UNITS
Dielectric Strength-Input/Output		1500	V (RMS)
Insulation Resistance @ 90 VDC-Input/Output		10^{12} @ 25°C - 50% RH	Ohms
Max. Capacitance-Input/Output		1.0	pF
Lead Temperature (1.6mm below seating plane) for 10 sec.		260	°C
Ambient Temperature Range:	Operating	-40 to 85	°C
	Storage	-40 to 100	°C

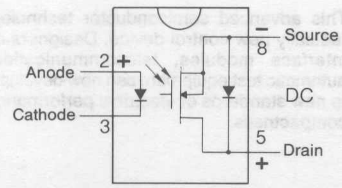
Mechanical Specifications:



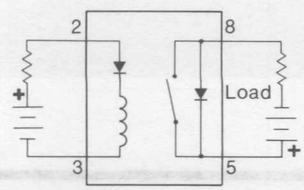
Dimensions: Inches (mm)
Package Size: 8 Pin DIP
Tolerances: .015 (.38) unless otherwise specified
Case Material: Molded epoxy
Weight: .07 oz. (2 grams)

Wiring Diagrams:

Schematic



Electromechanical Analogy



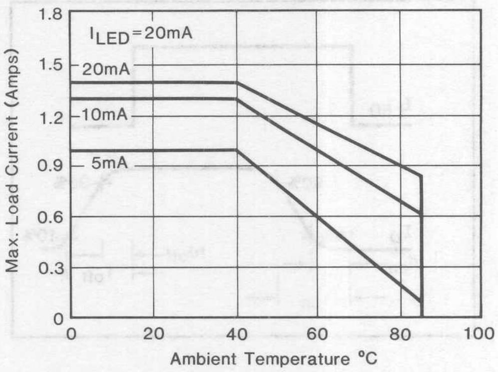


Figure 1. Current Derating Curves

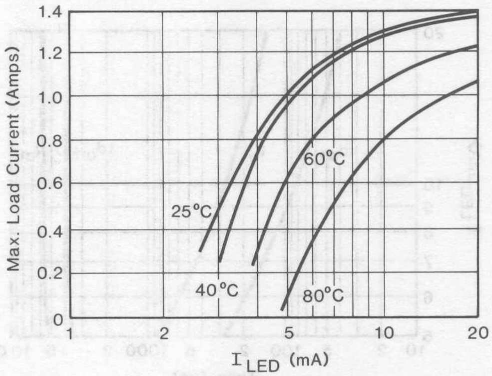


Figure 2. Typical Control Current Requirements

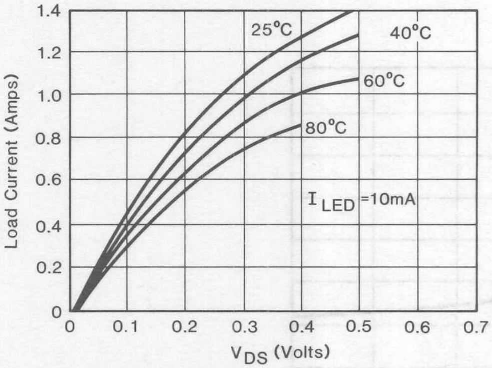


Figure 3. Typical On-Characteristics

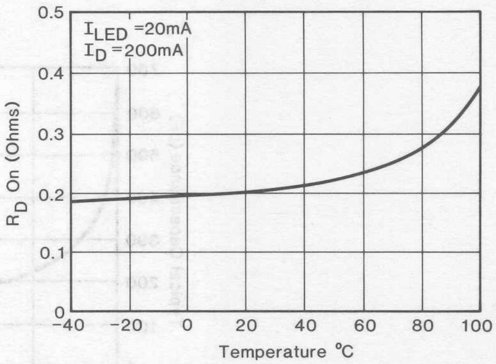


Figure 4. Typical On-Resistance

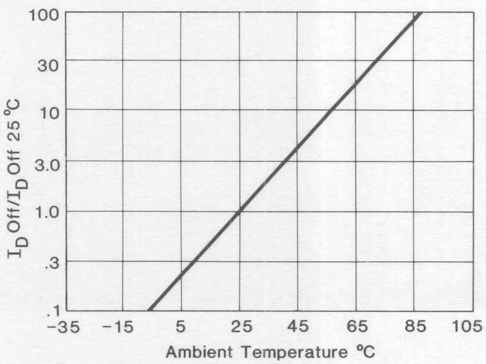


Figure 5. Normalized Off-State Leakage

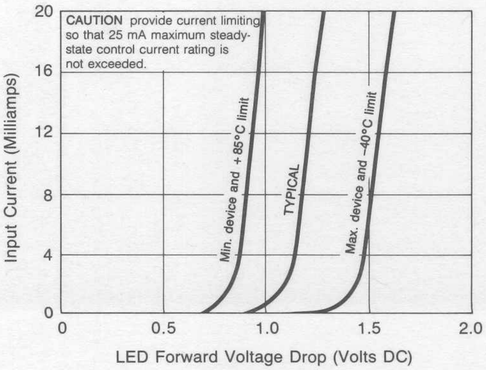


Figure 6. Input Characteristics (Current Controlled)

D

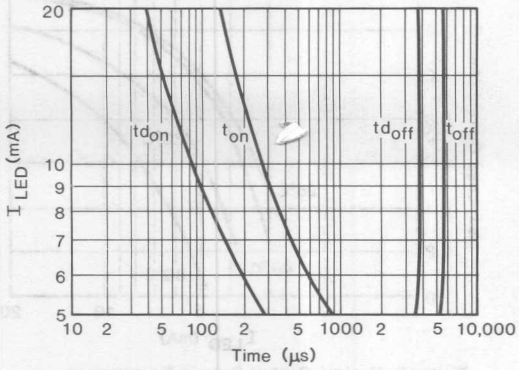


Figure 7. Typical Delay Times

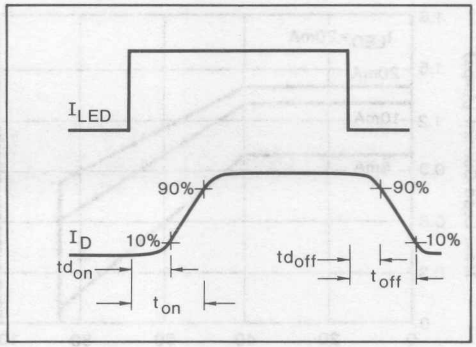


Figure 8. Delay Time Definitions

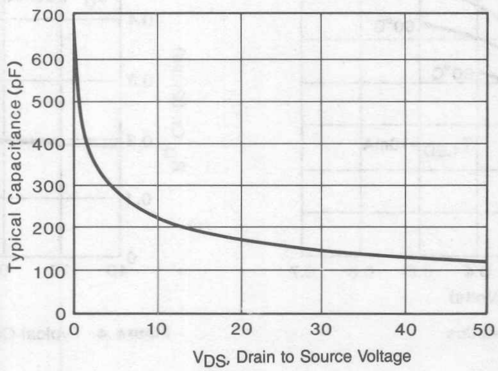


Figure 9. Typical Output Capacitance

Data Sheet No. PD-1.027B

INTERNATIONAL RECTIFIER IOR

SERIES PVR13

Microelectronic Power IC Relay

Two Pole, 400 mA
0-100V AC/DC

BOSFET® PhotoVoltaic Relay

GENERAL DESCRIPTION

The Photovoltaic Relay (PVR) is a two pole, normally open solid state replacement for electromechanical reed relays. It utilizes as an output switch a unique bidirectional (AC or DC) MOSFET power IC termed a BOSFET. The BOSFET is controlled by a photovoltaic generator of novel construction, which is energized by radiation from a dielectrically isolated light emitting diode (LED).

PVR FEATURES

The PVR overcomes the limitations of reed relays by offering the solid state advantages of long life, high operating speed, low pick-up power, bounce free operation, low thermal voltages and miniaturization. These advantages allow product improvement and design innovations in many applications such as process control, multiplexing, telecommunications, automatic test equipment, and data acquisition.

The PVR switches analog signals from thermocouple level to 100 volts peak AC or DC polarity. Signal frequencies into the RF range are easily controlled and switching rates up to 5 kHz are achievable. The extremely small thermally generated offset voltages allow increased measurement accuracies.

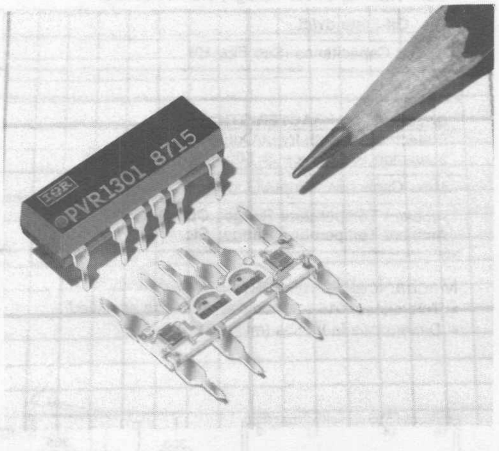
Unique silicon technology developed by International Rectifier forms the heart of the PVR. The monolithic BOSFET contains a bidirectional N channel power MOSFET output structure. In addition, this power IC chip has input circuitry for fast turn-off and gate protection functions. This section of the BOSFET chip utilizes both bipolar and MOS technology to form NPN transistors, P channel MOSFETs, resistors, diodes and capacitors.

The photovoltaic generator similarly utilizes a unique International Rectifier alloyed multi-junction structure. The excellent current conversion efficiency of this technique results in the very fast response of the PVR microelectronic power IC relay.

This advanced semiconductor technology has created a radically new control device. Designers can now develop switching systems to new standards of electrical performance and mechanical compactness.

(BOSFET. is a trademark of International Rectifier)

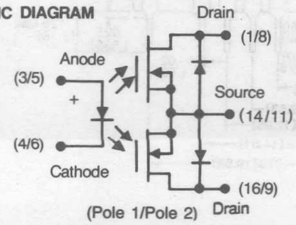
- BOSFET Power IC
- 10^{10} Operations
- 300 μSec Operating Time
- 0.2 μVolt Thermal Offset
- 5 milliwatts Pick-Up Power
- 1000V/μsec dv/dt
- Bounce Free
- 16 Pin Dip 2 Form A
- -40°C to 85°C



Part Identification

Part No.	Operating Voltage	Off-state Resistance
PVR1300	0–100V AC/DC	10^8 ohms
PVR1301		10^{10} ohms

SCHEMATIC DIAGRAM



BOSFET PVR13 PhotoVoltaic Relay

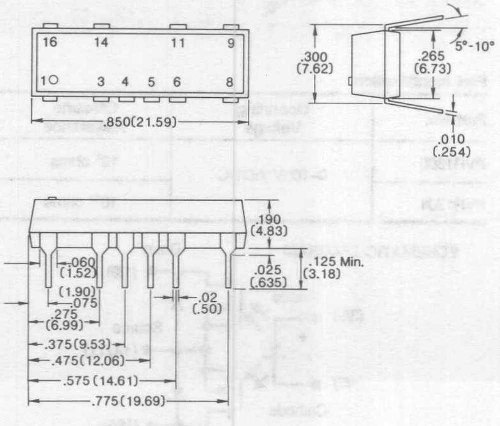
ELECTRICAL SPECIFICATIONS (–40°C ≤ T_A ≤ 85°C unless otherwise specified)

(See Wiring Diagrams)

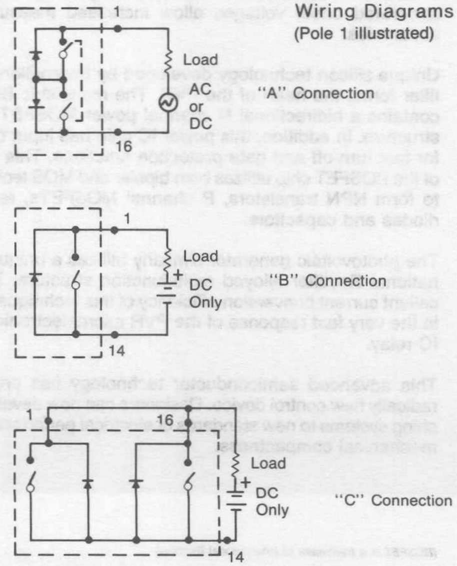
INPUT CHARACTERISTICS (See Fig. 4)	"A" Connection	"C" Connection	Units
Min. Allowable Control Current:			
For 100 mA Continuous Load Current @ 25°C	1	1	mA (DC)
For 400 mA Continuous Load Current @ 25°C	10	5	mA (DC)
For 100 mA Continuous Load Current @ 85°C	10	7	mA (DC)
Min. Turn-Off Current	10		μA (DC)
Min. Turn-Off Voltage	0.6		V (DC)
Control Current Range (Caution: Current limit input LED. See Fig. 9)	2.0 to 25		mA (DC)
Max. Reverse Voltage	7.0		V (DC)
Response Time (See Fig. 7)			
Max. $T_{(on)}$ @ 12 mA Control, 100 mA load, 100 VDC, 25°C, 0 to 90%	300		microsec
Max. $T_{(off)}$ @ 12 mA Control, 100 mA load, 100 VDC, 25°C, 100% to 10%	50		microsec
OUTPUT CHARACTERISTICS			
Operating Voltage Range	± 100	0 to + 100	V (peak)
Max. Load Current 40°C (See Fig. 1)	400	700	mA (DC)
Max. On-State Resistance 25°C (Pulsed) (See Fig. 2) (100 mA load, 12 mA Control)	5.0	1.5	Ohms
Min. Off-State Resistance at 80 VDC, 25°C — PVR1300	1 × 10^8		Ohms
Min. Off-State Resistance at 80 VDC, 25°C — PVR1301	1 × 10^{10}		Ohms
Max. Thermal Offset Voltage, 5.0 mA Control	0.2		μ volts
Min. Off-State dv/dt	1000		V μs
Output Capacitance (See Fig. 10)	20	40	pf @ 20 VDC
GENERAL CHARACTERISTICS			
Dielectric Strength-Input/Output	1500		V (RMS)
Insulation Resistance @ 500 VDC-Input/Output	10^{12} @ 25°C - 50% RH		Ohms
Max. Capacitance-Input/Output	1.0		pf
Ambient Temperature Range: Operating	-40 to 85		°C
Ambient Temperature Range: Storage	-40 to 100		°C

Mechanical Specifications:

- Tolerances .015 (.38) unless otherwise specified
- Dimensions in inches (millimeters)



Wiring Diagrams
(Pole 1 illustrated)



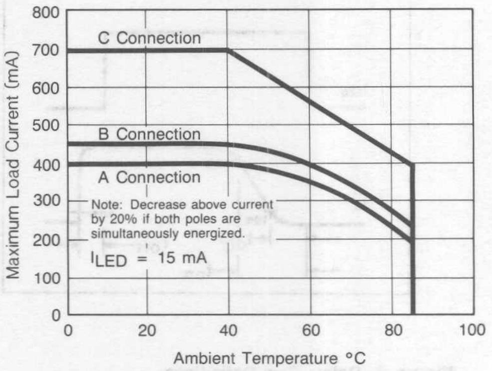


Figure 1. Current Derating Curve

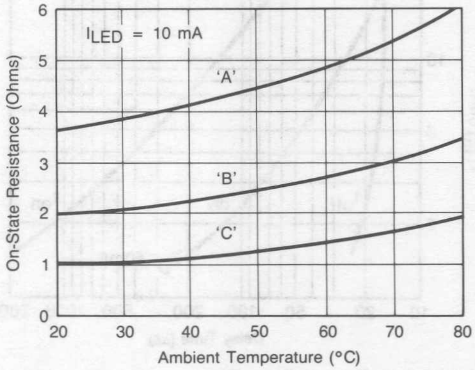


Figure 2. Typical On-Resistance

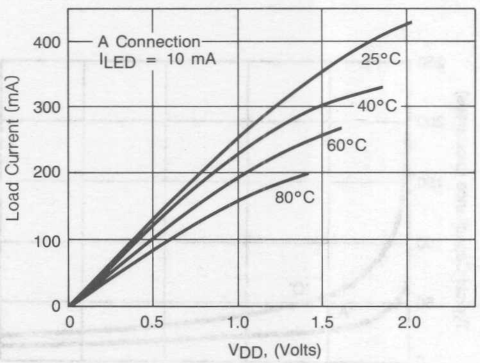


Figure 3. Typical On Characteristics

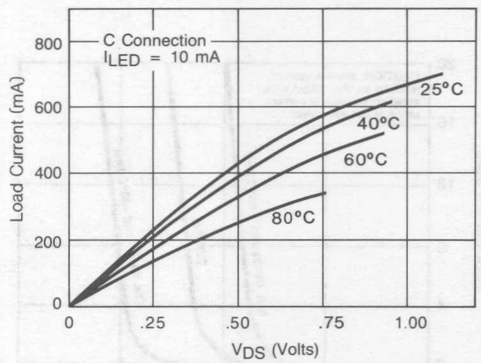


Figure 4. Typical On Characteristics

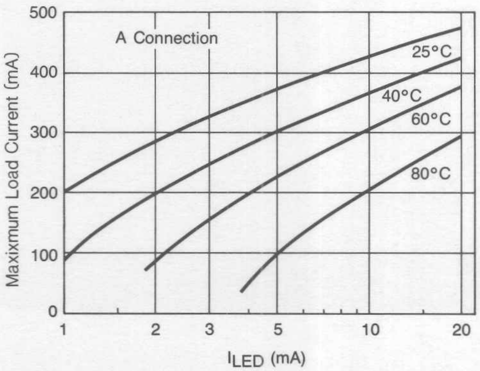


Figure 5. Typical Control Current Requirement

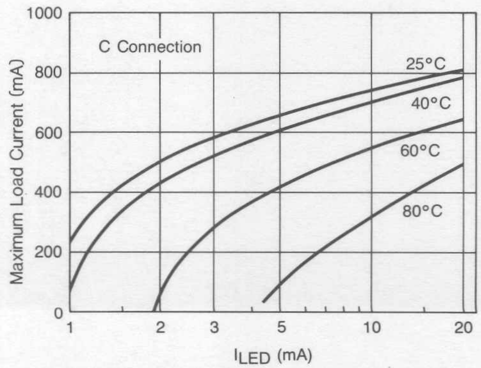


Figure 6. Typical Control Current Requirement

D

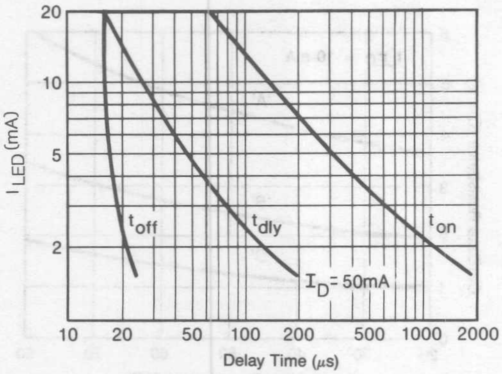


Figure 7. Typical Delay Times

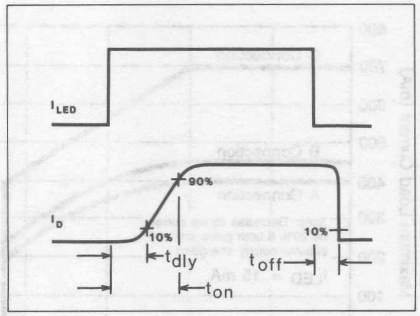


Figure 8. Delay Time Definitions

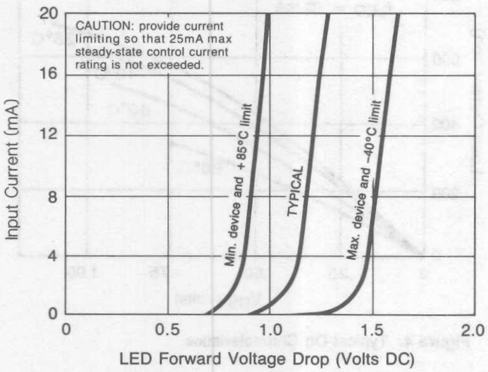


Figure 9. Typical Control Threshold and Transfer Ratio

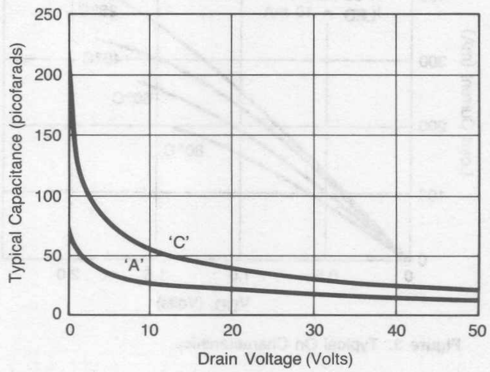


Figure 10. Typical Output Capacitance

INTERNATIONAL RECTIFIER IOR

SERIES PVR33

Microelectronic Power IC Relay

Two Pole, 180 mA
0-300V AC/DC

BOSFET® PhotoVoltaic Relay

GENERAL DESCRIPTION

The Photovoltaic Relay (PVR) is a two pole, normally open solid state replacement for electromechanical reed relays. It utilizes as an output switch a unique bidirectional (AC or DC) MOSFET power IC termed a BOSFET. The BOSFET is controlled by a photovoltaic generator of novel construction, which is energized by radiation from a dielectrically isolated light emitting diode (LED).

PVR FEATURES

The PVR overcomes the limitations of reed relays by offering the solid state advantages of long life, high operating speed, low pick-up power, bounce free operation, low thermal voltages and miniaturization. These advantages allow product improvement and design innovations in many applications such as process control, multiplexing, telecommunications, automatic test equipment, and data acquisition.

The PVR switches analog signals from thermocouple level to 300 volts peak AC or DC polarity. Signal frequencies into the RF range are easily controlled and switching rates up to 5 kHz are achievable. The extremely small thermally generated offset voltages allow increased measurement accuracies.

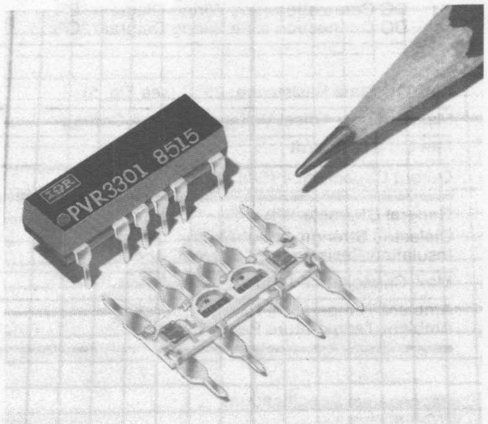
Unique silicon technology developed by International Rectifier forms the heart of the PVR. The monolithic BOSFET contains a bidirectional N channel power MOSFET output structure. In addition, this power IC chip has input circuitry for fast turn-off and gate protection functions. This section of the BOSFET chip utilizes both bipolar and MOS technology to form NPN transistors, P channel MOSFETs, resistors, diodes and capacitors.

The photovoltaic generator similarly utilizes a unique International Rectifier alloyed multi-junction structure. The excellent current conversion efficiency of this technique results in the very fast response of the PVR microelectronic power IC relay.

This advanced semiconductor technology has created a radically new control device. Designers can now develop switching systems to new standards of electrical performance and mechanical compactness.

(BOSFET is a trademark of International Rectifier)

- BOSFET Power IC
- 10^{10} Operations
- 100 μSec Operating Time
- 0.2 μVolt Thermal Offset
- 5 milliwatts Pick-Up Power
- 1000V/μsec dv/dt
- Bounce Free
- TO-116 Pinout
- -40°C to 85°C



Part Identification

Part No.	Operating Voltage	Off-state Resistance
PVR2300	0-200V AC/DC	10^8 ohms
PVR3300	0-300V AC/DC	
PVR3301		10^{10} ohms

D

BOSFET PVR33 PhotoVoltaic Relay

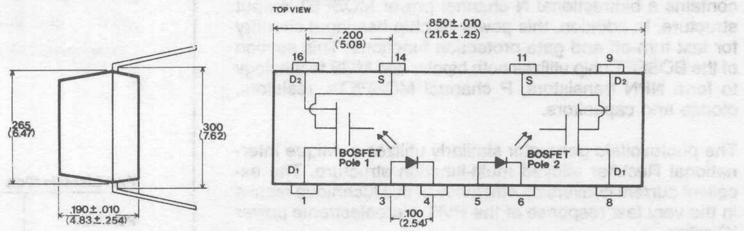
IOR

ELECTRICAL SPECIFICATIONS (−40°C ≤ T_A ≤ 85°C unless otherwise specified)	PART NO. PVR2300	PVR3300	PVR3301	Units
Input Characteristics (See Fig. 4)				
Min. Allowable Control Current:				
For 20mA Continuous Load Current.		2.0 @ 25°C		mA (DC)
For 100mA Continuous Load Current.		5.0 @ 25°C		mA (DC)
For 20mA Continuous Load Current.		5.0 @ 85°C		mA (DC)
Min. Turn-Off Current		10		μA (DC)
Min. Turn-Off Voltage		0.6		V (DC)
Control Current Range (Caution: Current limit input LED. See Fig. 6)		2.0 to 25		mA (DC)
Max. Reverse Voltage		7.0		V (DC)
Response Time (See Fig. 7)				
Max. $T_{(on)}$ @ 12 mA Control, 100 mA load, 100 VDC, 25°C., 0 to 90%		100		microsec
Max. $T_{(off)}$ @ 12 mA Control, 100 mA load, 100 VDC, 25°C., 100% to 10%		50		microsec
Output Characteristics				
Operating Voltage Range	0 ±200	0 ± 300		V (peak)
Max. Load Current 40°C (See Fig. 1)				
AC (See Wiring Diagram "A")		180		mA (peak)
DC (See Wiring Diagram "B")		200		mA (DC)
DC (See Wiring Diagram "C")		260		mA (DC)
Max. On-State Resistance 25°C (Pulsed) (See Fig. 2) (50 mA load, 8 mA Control)				
AC Connection (See Wiring Diagram "A")		24		Ohms
DC Connection (See Wiring Diagram "B")		12		Ohms
DC Connection (See Wiring Diagram "C")		6		Ohms
Min. Off-State Resistance, 25°C (see Fig. 5)	10^8 @ 160VDC		10^{10} @ 240VDC	Ohms
Max. Thermal Offset Voltage, 5.0 mA Control		0.2		μ volts
Min Off-State dv/dt		1000		v/μs
Output Capacitance (See Fig. 3)		12		pf @ 50 VDC
General Characteristics				
Dielectric Strength-Input/Output		1500		V (RMS)
Insulation Resistance @ 500 VDC-Input/Output		10^9		Ohms
Max. Capacitance-Input/Output		1.0		pf
Ambient Temperature Range: Operating		-40 to 85		°C
Ambient Temperature Range: Storage		-40 to 100		°C

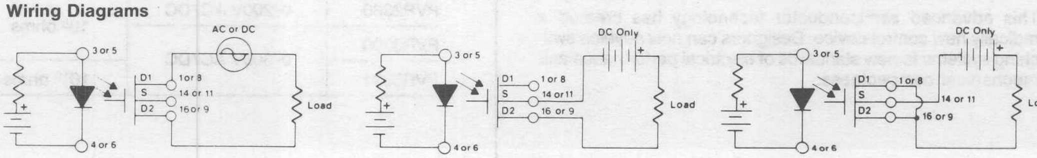
Mechanical Specifications

TO-116 Pinout

Dimensions in Inches (Millimeters)



Wiring Diagrams



"A" Connection "B" Connection "C" Connection

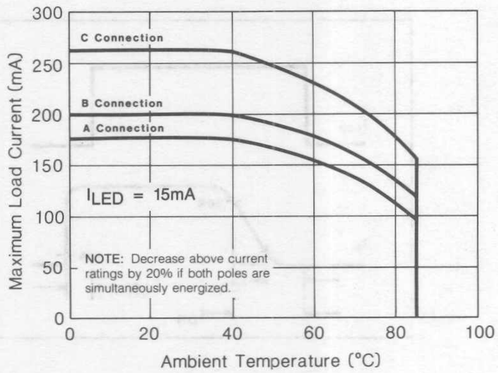


Figure 1. Current Derating Curve

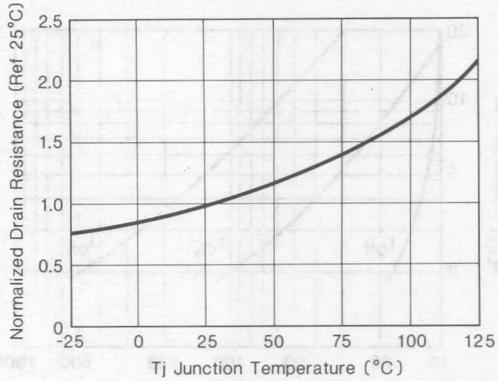


Figure 2. Typical Normalized On-Resistance

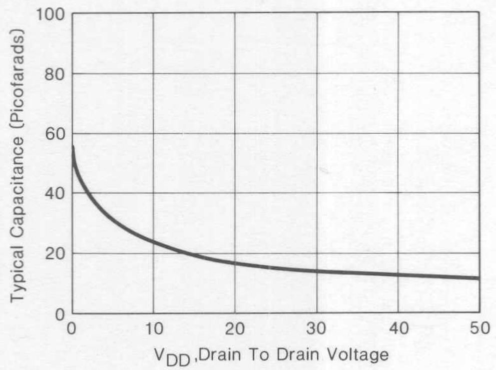


Figure 3. Typical Output Capacitance

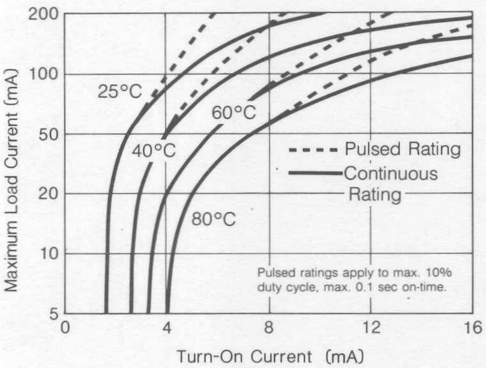


Figure 4. Minimum Control Current For Full Turn-On

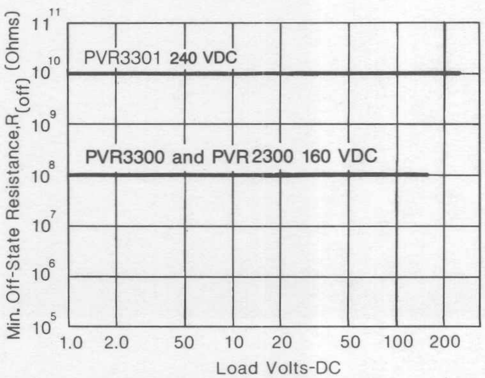


Figure 5. Off-State Resistance

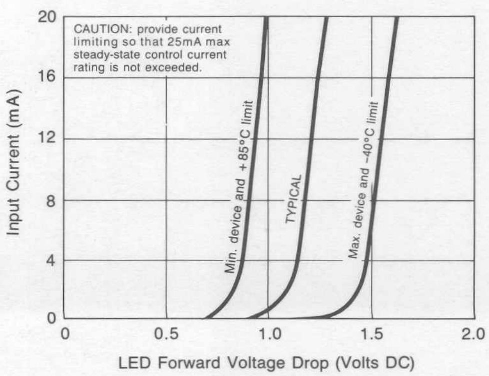


Figure 6. Input Characteristics (Current Controlled)

D

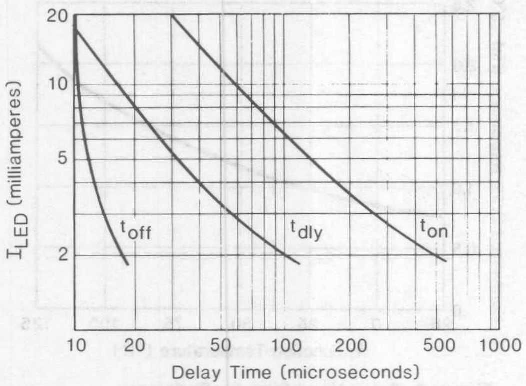


Figure 7. Typical Delay Times

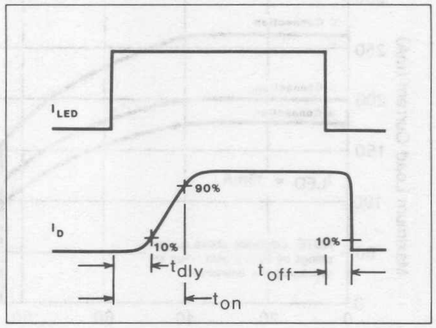


Figure 8. Delay Time Definitions

INTERNATIONAL RECTIFIER IOR

SERIES PVI
Microelectronic
Isolator

5 or 10 Volt
Output

PhotoVoltaic Isolator

GENERAL DESCRIPTION

The PhotoVoltaic Isolator (PVI) generates an electrically isolated DC voltage upon receipt of a DC input signal. The input of the PVI is a Light-Emitting Diode (LED) which is optically coupled to, but electrically isolated from, the output. A gallium aluminum-arsenide LED is used for high output and maximum stability. The infrared emission from the LED energizes, by photovoltaic action, a series connection of silicon pn junctions. A unique alloyed junction stack which is edge illuminated is used to form the output photovoltaic generator. This novel International Rectifier structure produces extremely high operating efficiency. Units are available with a single 5 volt output or dual 5 volt outputs which can be series connected to produce 10 volts.

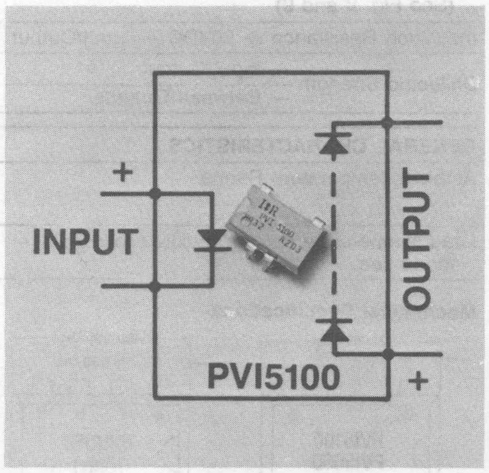
PVI FEATURES

A photovoltaic isolator can serve as an isolator, a coupler or as an isolated voltage source. As an isolator the PVI can serve as the key component in a solid state relay circuit. The PVI is ideally suited for driving power MOSFETs or sensitive gate SCRs to form solid state relays.

As a coupler the PVI can sense a low level DC signal and transmit a voltage signal to an electrically remote circuit. As a voltage source the PVI can function as a "DC transformer' by providing an isolated, low current DC source for biasing or supplying power to low quiescent current electronic devices.

Conventional photocouplers merely modulate the resistance of an output device such as a transistor, diode or resistor. Such photocouplers require a separate voltage source to detect the presence of an input signal. In contrast, a PVI actually transmits (and transforms) energy across the isolation barrier and directly generates an output voltage. This DC voltage, available at a 2500 VAC isolation level, gives circuit designers a new and uniquely useful electronic component.

- **Isolated Voltage Source**
- **MOSFET Driver**
- **Up to 50 μA Output**
- **Fast Response**
- **GaAlAs LED**
- **2500V (RMS) Isolation**
- **8-Pin DIP Package**
- **Single or Dual Output**



Part Identification

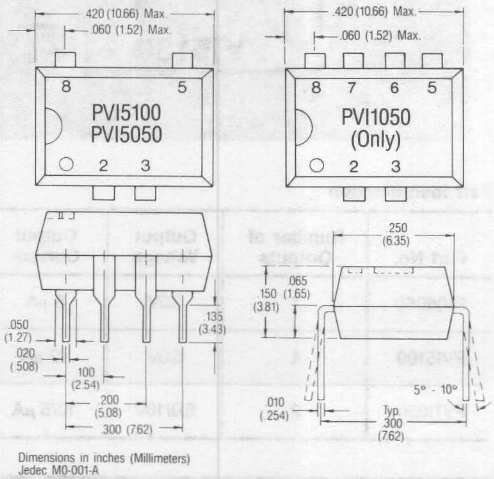
Part No.	Number of Outputs	Output Voltage	Output Current
PVI5050	1	5.0V	5 μA
PVI5100	1	5.0V	10 μA
PVI1050	2	5.0/10V	10/5 μA

IOR

ELECTRICAL SPECIFICATIONS ($-40°C \leq T_A \leq 100°C$ unless otherwise specified)

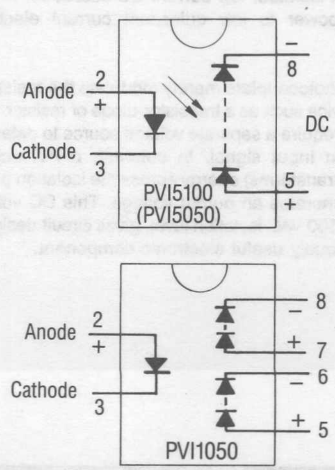
INPUT CHARACTERISTICS (LED Emitter)		PART NUMBER			UNITS
		PVI5050	PVI5100	PVI1050	
Input Current Range (See Fig. 5)		2.0 to 50			mA (DC)
Max. Forward Voltage Drop @ 10mA, 25°C (See Fig. 6)		1.4			V (DC)
Max. Reverse Voltage		7.0			V (DC)
Max. Reverse current @ −7.0V (DC), 25°C		100			μA (DC)
Max. Pulsed Input Current @ 25°C (See Fig. 7)		1.0			A (Peak)
OUTPUT CHARACTERISTICS (PhotoVoltaic Generator Detector)					
Max. Forward Voltage @ 10μA		8.0 Per Channel			V (DC)
Max. Reverse Current @ −10V (DC)		10			μA (DC)
COUPLED CHARACTERISTICS					
Min. Open Circuit Voltage @ 10mA, 25°C (See Figs. 1, 2, 3 and 4)		5.0V		5.0V Per Channel 10V Series Connection	V (DC)
Min. Short Circuit Current @ 10mA, 25°C (See Figs. 1, 2, 3 and 4)		5 μA	10μA	5.0 μA Per Channel 10 μA Parallel Connection	μA (DC)
Max. Capacitance — Input/Output		1.0		2.0	pF
Max. Turn-on Time @ 20mA Input, 25°C, 0 to 90% (See Fig. 8 and 9)	R_L = 5.0 MΩ	30	10	30	μs
	R_L = 1.0 MΩ	40	12	40	μs
Max. Turn-off Time @20mA, 25°C 100% to 10% (See Fig. 8 and 9)	R_L = 5.0 MΩ	400	300	400	μs
	R_L = 1.0 MΩ	100	80	100	μs
Insulation Resistance @ 90VDC — Input/Output		10^{12}			Ω
Dielectric Strength — Input/Output		2500			V (RMS)
Dielectric Strength — Between Outputs		N/A		1200	V (DC)
GENERAL CHARACTERISTICS					
Ambient Temperature Range	Operating	−40 to 100			°C
	Storage	−40 to 100			°C
Lead Temperature (1.6 mm below seating plane) for 10 sec.		260			°C

Mechanical Specifications



Dimensions in inches (Millimeters)
Jedec M0-001-A

Wiring Diagram/Schematic



PhotoVoltaic Isolator PVI5100, PVI5050 and PVI1050

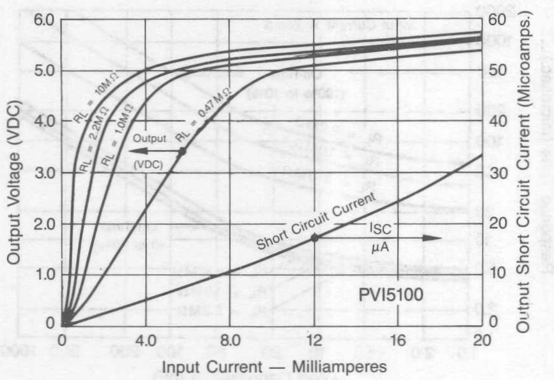


Figure 1. PVI5100 Typical Output Characteristics

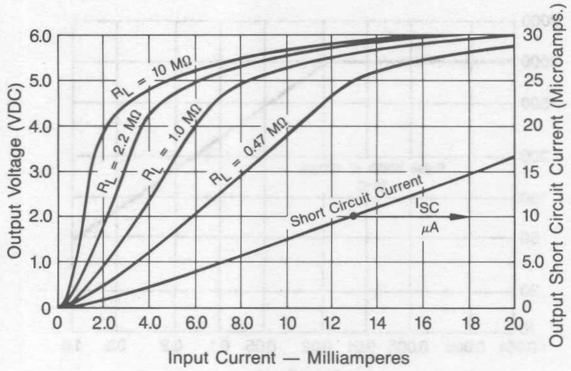


Figure 2. PVI5050 Typical Output Characteristics

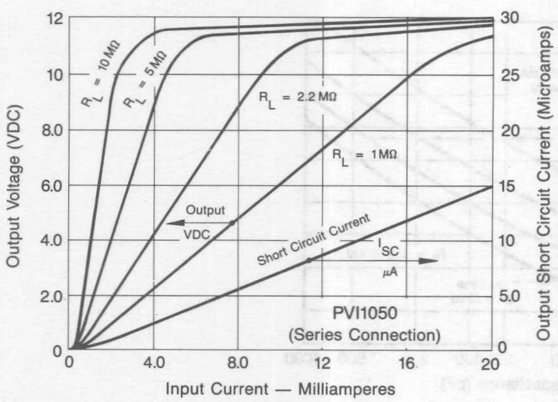


Figure 3. PVI1050 Typical Output Characteristics

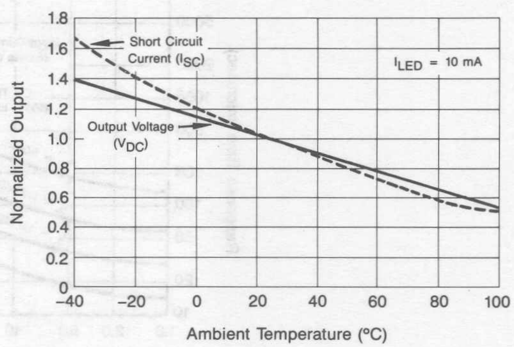


Figure 4. Typical Variation of Output

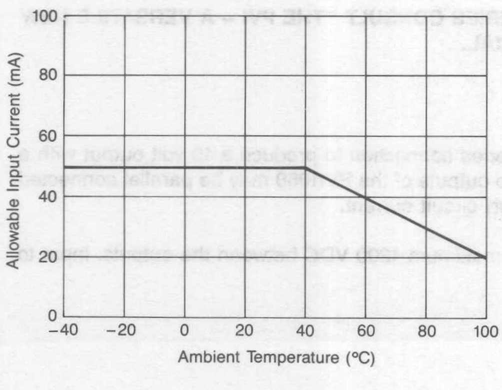


Figure 5. Input Current Derating

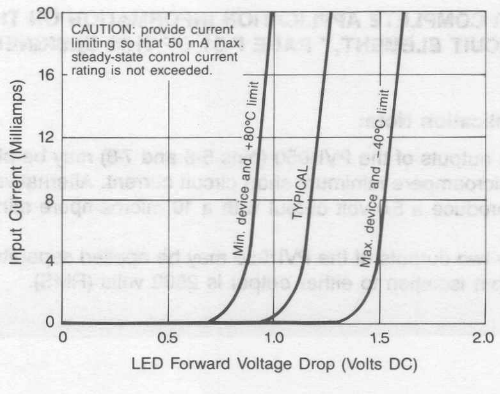


Figure 6. Input Characteristics

E

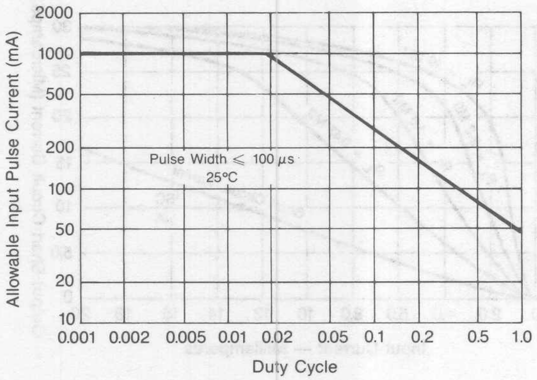


Figure 7. Input Pulse Capability

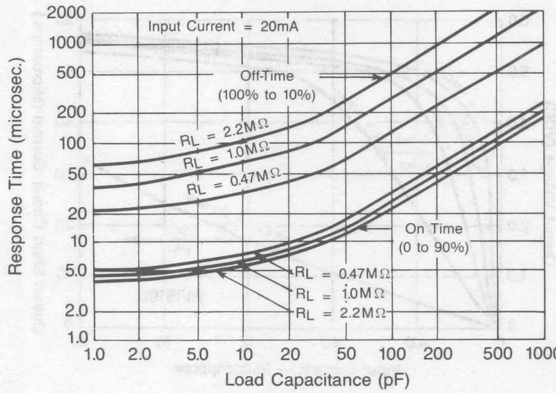


Figure 8. PVI5100 Typical Response Time

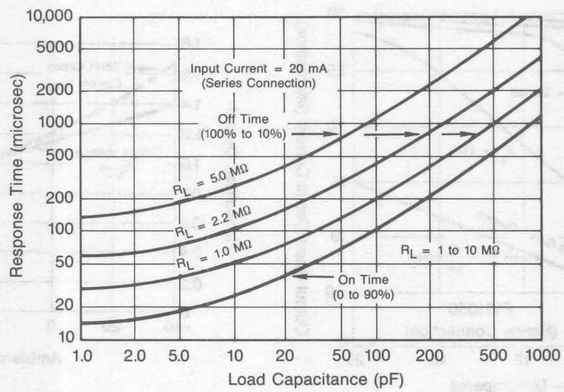


Figure 9. PVI1050 (PVI5050) Typical Response Time

FOR COMPLETE APPLICATION INFORMATION ON THE PVI SERIES CONSULT "THE PVI – A VERSATILE NEW CIRCUIT ELEMENT," PAGE F-31 OF THIS DESIGNER'S MANUAL.

Application Note:

The outputs of the PVI1050 (pins 5-6 and 7-8) may be placed in series connection to produce a 10 volt output with a 5 microampere minimum short circuit current. Alternatively, the two outputs of the PVI1050 may be parallel connected to produce a 5.0 volt output with a 10 microampere minimum short circuit current.

The two outputs of the PVI1050 may be applied separately with a maximum 1200 VDC between the outputs. Input to output isolation to either output is 2500 volts (RMS).

Microelectronic Relay

Designer's Manual

Index to Application Notes

F

Microelectronic Relay

Designer's Manual

International Rectifier

AC Load Switching With ChipSwitch® Microelectronic Relays

AN-100

(ChipSwitch is a trademark of International Rectifier)

by Stan Schneider

Introduction

Electromechanical relays (EMRs) used for switching AC lines have limited useful lives due to mechanical wear out and contact sticking and erosion. These problems are accentuated under inductive loads or the surge conditions experienced when driving incandescent lamps. Under these conditions relay life varies from 10^4 to 10^6 operations.

The ChipSwitch Relay

The ChipSwitch microelectronic relay developed by International Rectifier is a solid state device specifically designed to overcome EMR problems through the use of electronic power switching. Mechanical fatigue and contact arcing problems under inductive loads, for example, are totally non-existent. Because of this superior performance, ChipSwitch relays offer designers a far better solution where reliability of operation and the high cost of service are important factors.

Power IC Approach

The use of an integrated circuit approach to zero-crossing, photosensing and power switching combined with the use of the highly advantageous dual SCR output, produces a microelectronic relay with a very long switching life. In order to determine the switching life of the ChipSwitch SSR a number of characteristic loads were selected. These included contactor coils, solenoid valves and incandescent lamps. These loads presented a wide variety of severe operating conditions. The test data in this application note indicates a minimum life of 10^7 operations with no upper limit yet established — demonstrating that the ChipSwitch relay's switching life exceeds that which can be achieved by EMR devices. The lack of any deterioration in the ChipSwitch test samples further indicates that actual life is much greater.

SOLENOID VALVES

Scope: To determine the feasibility of employing the CS6005 and CS6010 ChipSwitch relays to switch solenoid operated gasoline valves.

Life Test Description: Two typical dual flow rate valves were selected and set up to be switched by ChipSwitch solid-state relays. Each of the valves selected used two ChipSwitch devices to operate at the two flow rates required.

For each valve two tests were run: one full-off to full-on; and the second full-off to full-on to half-on (low flow rate).

TEST I

Valve: Skinner XLG2R470C

Relays: Two ChipSwitch CS6010 (CS6005 is identical except for turn-on current).

Test A: Both coils on and off simultaneously (Full-on, Full-off).

Input Current (each ChipSwitch):	10 mA DC
Cycle Length:	1 Sec.
Duty Cycle:	50%
Steady State Operating Current	
ChipSwitch 1:	180 mA AC Peak
ChipSwitch 2:	180 mA AC Peak
Test Duration:	2,074,000 Cycles

Test B: Both coils on simultaneously, low flow rate coil on only, off

Input Current (each ChipSwitch)	10 mA DC
Cycle Length:	3 Sec.
Duty Cycle:	1 Sec. Full on 1 Sec. Low Flow Rate 1 Sec. Off
Steady State Operating Current	
Full On	
ChipSwitch 1:	180 mA AC Peak
ChipSwitch 2:	180 mA AC Peak
Low Flow Rate	
ChipSwitch 1:	180 mA AC Peak
ChipSwitch 2:	0
Test Duration:	864,000 Cycles
Total Test Duration:	2,938,000 Cycles

F

TEST II

Valve: ASCO 8292

Relays: Two ChipSwitch CS6010

Test A: Both coil and diode circuit on and off simultaneously (Full on, Full off)

Input Current:	10 mA DC
Cycle Length:	1 Sec.
Duty Cycle:	50%
Steady State Operating Current	
ChipSwitch 3:	270 mA
ChipSwitch 4:	150 mA
Test Duration:	3,197,000 Cycles

Test B: Both coil and diode circuit on simultaneously, coil on only, off.

Input Current:	10 mA DC
Cycle Length:	3 Sec.
Duty Cycle:	1 Sec. Full On 1 Sec. Low Flow Rate 1 Sec. Off
Steady State Operating Current	
Full on	
ChipSwitch 3:	270 mA AC Peak
ChipSwitch 4:	150 mA AC Peak
Low Flow Rate:	
ChipSwitch 3:	170 mA AC Peak
ChipSwitch 4:	0
Test Duration:	864,000 Cycles
Total Test Duration:	4,061,000 Cycles

Life Test Results

The ChipSwitch relays were removed from the circuit after each test and completely checked for any detrimental effects to the operating characteristics. Each SSR was found to be in perfect operating condition and no degradation in any specification was detected.

Conclusion

The tests performed show that the ChipSwitch CS6005 and CS6010 microelectronic power IC relays can successfully and reliably operate solenoid controlled valves. □

CONTACTORS AND INCANDESCENT LAMPS

Scope: To determine the feasibility of employing the ChipSwitch CS6005 and CS6010 microelectronic relays to switch size 1 and size 2 contactors and incandescent lamps.

Life Test Description: Both size 1 and size 2 contactor and a 25 watt incandescent lamp were selected and set up to be operated by ChipSwitch relays. The size 1 contactor, the size 2 contactor, and the incandescent lamp were each driven by a single ChipSwitch. The test in all cases consisted of a simple on/off sequential operation.

TEST I

Contactor: Telemecanique (Gould) Size 1 Contactor Catalog #A203C, 120 VAC Coil (38 Ohm Dc Resistance)

Relay: ChipSwitch CS6010 (CS6005 is identical except for turn-on current).

Control Input: 10 sec, 10 mA pulse, 20 sec. period

Test Data

	Open	Sealed
Line Voltage:	120 VAC	120 VAC
Current:	1.65A RMS	0.20A RMS
Phase Shift:	56 Deg.	73 Deg.
Power Factor:	0.56	0.29

Contactor closes within 1 cycle

Test Duration: 1,132,000 Cycles

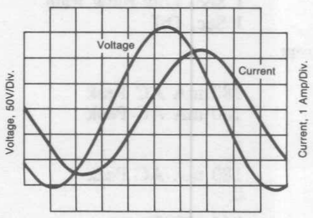


Figure 1. Open Condition

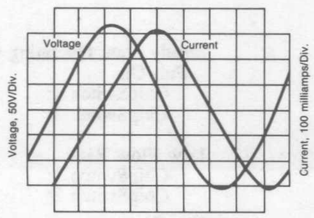


Figure 2. Sealed Condition

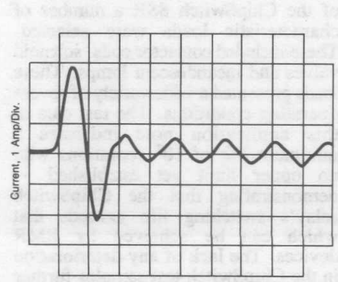


Figure 3. Switched Coil Current

TEST II

Contactor: Westinghouse size 2 Contactor
Catalog #A201K2CA
120 VAC coil (41 ohm DC resistance)

Relay: ChipSwitch CS6010

Control Input: 10 sec, 10 mA pulse, 20 sec. period

Test Data

	Open	Sealed
Line Voltage:	120 VAC	120 VAC
Current:	1.34A RMS	0.20A RMS
Phase Shift:	56 Deg.	73 Deg.
Power Factor:	0.56	0.29

Contactor closes in 1 cycle

Test Duration: 1,132,000 Cycles

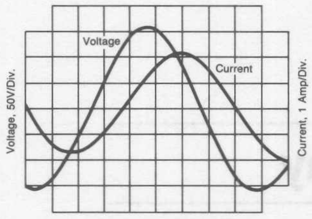


Figure 4. Open Condition

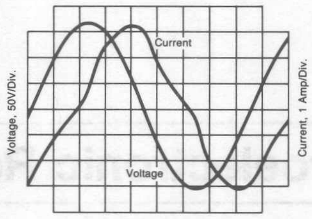


Figure 5. Sealed Condition

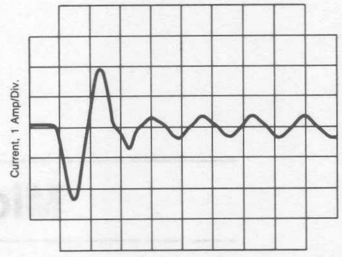


Figure 6. Switched Coil Current

TEST III

Lamp: 25 Watt Incandescent Lamp
120 VAC filament

Relay: ChipSwitch CS6010

Control Input: 10 sec, 10 mA pulse, 20 sec. period

Test Data

Line Voltage:	120 VAC
Peak Current:	1.6A 1st ½ cycle
Steady State:	0.25A RMS
1st ½ Cycle:	0.70A RMS
1st Full Cycle:	0.39A RMS

Lamp Current stabilizes rapidly in first cycle.

Test Duration: 1,132,000 Cycles

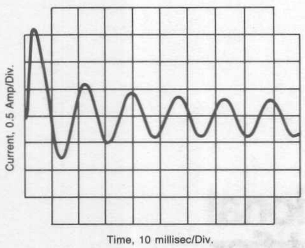


Figure 7. Lamp Current

Lamp load rating is determined by the steady state current of the lamp independent of the flashing rate.

Life Test Results

The ChipSwitch devices were removed from the circuit after each test and completely checked for any detrimental effects to the operating characteristics. Each SSR was found to be in perfect operating condition and no degradation in any specification was detected.

Conclusion

The test performed shows that the ChipSwitch CS6005 and CS6010 microelectronic power IC relays can successfully and reliably operate the size 1 and size 2 contactors and incandescent lamps. □

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Microelectronic Relay

Designer's Manual

International
IOR Rectifier

Choosing An Input Resistor for a Microelectronic Relay

by Bill Collins

Introduction

The International Rectifier Chip-Switch and PhotoVoltaic Relay (PVR) devices are current-controlled microelectronic relays with a specified current which must be supplied for turn-on. Therefore, a current limit resistor is necessary when operating from a voltage source. This application note gives the procedure for determining the proper resistor to program the microelectronic relays to operate from any control voltage.

Procedure

The selected resistor must be of sufficiently low value that the specified turn-on current flows at the minimum signal voltage and lowest operating temperature. Note that the input circuit shown in Figure 1 consists of the internal Light Emitting Diode (LED) plus the external resistor which is being selected.

To determine the maximum allowable value of R_C, the maximum LED forward voltage drop at the coldest operating temperature should be determined from the input characteristics curve found in each respective technical data sheet. An example is shown here as Figure 2.

The value normally used for −40°C operation is 1.6 VDC. The following equation expresses the maximum allowable value for R_C.

$$R_C \leqq \frac{E_{in} - E_{LED}}{I_C \text{ (turn-on current)}}$$

Example: E_{in} (Min.) = 4.5 VDC; I_C = 5 mA; $T_A \geqq -40°C$

$$R_C \leqq \frac{4.5V - 1.6V}{.005A} \leqq 580 \text{ Ohms}$$

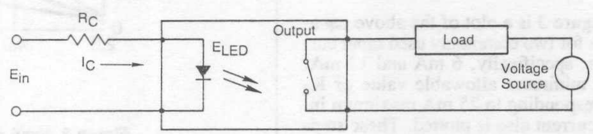

Figure 1. Input Circuit

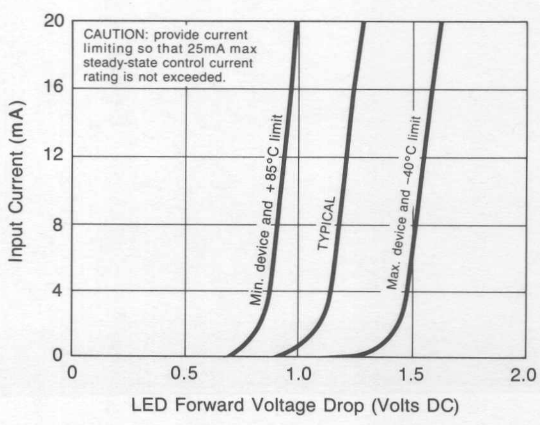

Figure 2. Input Characteristics (Current Controlled)

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A minimum allowable value of R_C is set by the necessity of not allowing the input current to exceed 25milliamperes at the highest signal voltage and maximum operating temperature. A high temperature LED drop of 0.9 volts is most commonly used.

$$R_C \geqq \frac{E_{in} - E_{LED}}{I_C \text{ (Max. Allowable Current)}}$$

Example: $E_{in} = 6.0V$ Max; I_C Max. = 25 mA, $T_A \leqq 85°C$.

$$R_C \geqq \frac{6.0V - 0.9V}{.025A} \geqq 204 \text{ Ohms}$$

In the above examples a resistor in the calculated range and near the maximum allowable value would be selected, for example 500 Ohms.

Figure 3 is a plot of the above equations for two commonly used input currents: specifically, 6 mA and 12 mA. The minimum allowable value of R_C corresponding to 25 mA maximum input current also is plotted. These steps should be followed to determine an appropriate input resistor.

1. Determine the minimum available input voltage and read the maximum allowable R_C from the plot corresponding to the selected signal current (in this case, 6 mA or 12 mA).

2. Read the maximum allowable input voltage for the selected resistor value by checking the bottom "minimum allowable R_C" plot. The allowable input signal voltage range has now been determined. Note that by reading horizontally across a given input resistor value from the "Signal Plot" to the "Minimum Allowable R_C" plot the allowable input voltage range can be directly observed. □

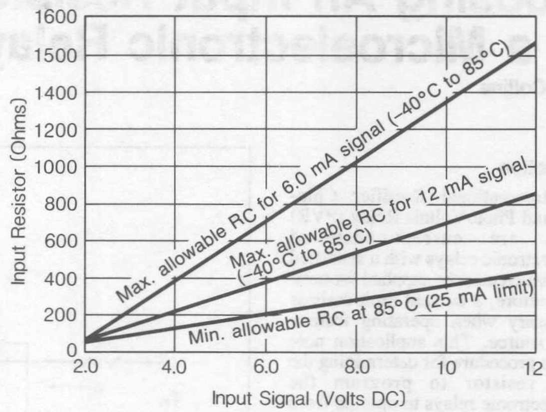

Figure 3. Input Resistor For Two Typical Input Currents

Inductive Load Switching Characteristics of the ChipSwitch®

(ChipSwitch is a trademark of International Rectifier)

by Stan Schneider

Introduction

Due to their unique switching characteristics, solid state relays (SSRs) have firmly established themselves as electronic switches in the world of industrial controls. Many of the loads encountered in this world are inductive, from moderately inductive motors and transformers to extremely inductive solenoids and contactors. When switching such loads, the AC current lags the AC voltage, thus creating a phase angle difference commonly specified as power factor. Power factor is defined as R/Z or the cosine of the phase angle difference between voltage and current and decreases with increasingly inductive loads.

This phase difference has in the past caused switching problems for SSRs, especially those designed to switch at the advantageous zero voltage crossing point of the line, as in the case of International Rectifier's ChipSwitch microelectronic relay. For these reasons most SSRs are rated at a minimum power factor of 0.5, while the ChipSwitch solid state device is rated at a greatly improved minimum of 0.2. Further, the 0.5 power factor rating has been achieved with the use of internal snubbers which, while improving inductive load capability, increase off-state leakage and reduce reliability. The ChipSwitch meets its 0.2 minimum power factor without the use of snubbers. It is the purpose of this application note to indicate the wide safety margin in the unsnubbered 0.2 power factor specification of the ChipSwitch relay and to establish that the performance is maintained over life.

Possible SSR Switching Problems

The inductive effects that could limit performance are those that occur during or following current transitions such as partial turn-on (half-waving) and failure to turn-off (lock-on). In the case of half-waving, the reapplied voltage traverses the zero switching window too fast to trigger the thyristor due to current phase shift in each previous half cycle (Figure 1 Condition A). Lock-on is where retriggering occurs every half cycle (with no input signal) due to the rapidly rising reapplied voltage (dv/dt), a totally different phenomenon, but also a result of the current phase shift (Figure 1 — Condition B). Increased junction temperature tends to increase the relay's susceptibility to this phenomenon.

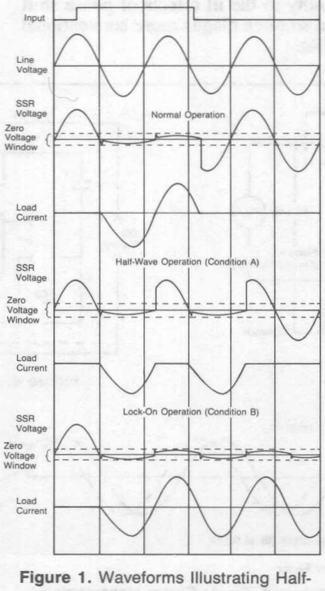

Figure 1. Waveforms Illustrating Half-Wave and Lock-On Phenomena

Power Factor Testing

The initial testing was performed with a load bank of passive inductors (chokes) and resistors that were adjusted to provide the appropriate load and power factor for each test condition. A series of tests were then made on a number of ChipSwitch relays using the test set-up of Figure 2. In order to detect a malfunction, the samples were examined at both turn-on and turn-off, as well as for symmetry of waveform at each test point.

The test samples were selected randomly from past and present production lots and were put through the normal final test procedure.

Samples were tested over a power factor range from 0.5 to 0.1 as measured on an oscilloscope (Figure 3) under the following conditions:

Ambient Temperature:	Room (25°C)
Input Current:	5 mA DC
Output Voltage:	5V, 140V, 280V (RMS)
Load Current:	5 mA,20 mA,300 mA, 650 mA, 1A (RMS) (But not greater than the rated current for each model).

Test Results

All samples operated correctly over the entire range of power factor.

Over Temperature Testing

In order to force a failed condition or a malfunction, five ChipSwitch relays were deliberately heated beyond the maximum specified full load 40°C

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ambient and the power factor of the load was varied over the same range as in the previous test. In the range of 40 to 50°C above specification and at full rated current, parts began to lock-on, but would recover when cooled. With resistive loads even higher temperatures were attained without lock-on. From this it is clear that, the dv/dt of the reapplied voltage, as is the normal case, is the cause of lock-on. It is also clear that a very large safety margin has been built into the ChipSwitch design.

Life Cycle Testing

While the previous tests confirm performance with passive inductive loads of varying power factors, it was felt that a practical test with a highly inductive, high inrush load would be in order. A NEMA No. 2 motor starter was chosen with the following coil characteristics:

	VA	Watts	Power Factor	Amps
Inrush	360	—	—	3.3
Sealed	41	10	0.24	0.37

With 5 mA of control current five ChipSwitch microelectronic relays were operated 100,000 times with a 50% duty cycle and a 10 second period.

Test Results

No malfunction occurred during the entire test duration and the ChipSwitch relays when retested showed no deterioration in specification. These results have been re-confirmed by additional testing as reported in Application Note AN-100.

Analysis of ChipSwitch Performance

The problems that might have afflicted conventional SSRs when subjected to the same series of tests were described in earlier paragraphs. Some of the reasons why the ChipSwitch was successful in these cases, even without a snubber, are as follows:

The two independently fired photo coupled switches, IC_1 and IC_2 shown in Figure 4, do not have the recovery time problems that might occur with a single SCR in a full-wave bridge circuit or with a triac which is used in many discrete SSRs. With the input energized the very fast turn-on properties of these SCRs allow the device to have sufficient time to turn-on when subjected to the step function reapplied line voltage at zero current. This insures that half-waving cannot occur.

The novel zero voltage detection and clamping circuit formed by C1, distributed gate capacitor C2, and FET Q1 effectively protects the SCR from turning on under the conditions of high reapplied dv/dt occurring when the ChipSwitch relay is turned off. Therefore, lock-on cannot occur under specified conditions.

Conclusions

In this application note we have shown the excellent inductive load switching capabilities of the ChipSwitch solid state relay and its inherent immunity to the ill effects of phase shift that so often plague more conventional SSRs.

Although no lower limit for power factor was found, the ChipSwitch can clearly operate loads with power factor magnitudes down to 0.1, thus assuring its successful use in what must be its greatest area of application. For example, the majority of motor starters and contactors have power factors between 0.15 and 0.4.

The unwillingness of the ChipSwitch microelectronic relay to half-wave, even well beyond its specification is tremendously important with inductive loads such as transformers that are prone to saturation. The DC component produced by a half-waving SSR can bring about saturating currents that result in its own destruction. The ChipSwitch will not self destruct in this manner and will provide dependable performance in an area that has long been questionable for SSRs.

Finally, the absence of a snubber and the ChipSwitch relay's inherently low leakage permit the switching of small, highly inductive loads at low voltage (e.g., 5 mA at 20 VAC and 0.1 pF). These characteristics together with a small zero switching window make International Rectifier's ChipSwitch microelectronic relay unique among AC SSRs.☐

References

1. International Rectifier Application Note AN-100. "The Switching Life of ChipSwitch Microelectronic Relays."

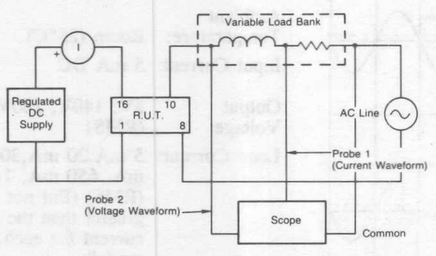

Figure 2. Test Set-Up

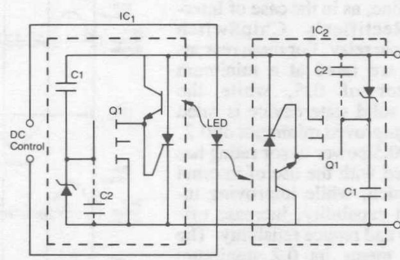

Figure 4. ChipSwitch Equivalent Circuit

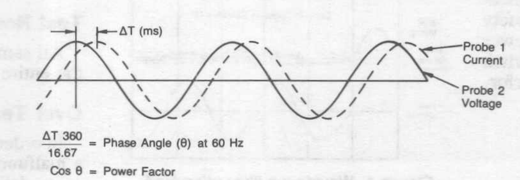

Figure 3. Power Factor Measurements

Thermal Evaluation of the ChipSwitch in Programmable Controllers

AN-103

by Stan Schneider

Introduction

International Rectifier single in-line package (SIP) microelectronic power IC relays are commonly applied as AC output interface units in programmable controller output assemblies. The most typical mechanical configuration consists of eight or more SIP relays attached to a common heatsink. This heatsink is usually part of or thermally tied to the case of the AC output module. The current handling capability of such an output assembly must be determined under various combinations of load current occurring in the individual channels. Obviously, the effective current rating of a given output channel is greatest when only that channel is turned on and only its power dissipation is contributing to the temperature rise of the large heatsink. Several channels turned on simultaneously result in more heating and a reduction of the allowable current rating of the individual channels.

The SIP ChipSwitch

This application note presents the test technique for determining the allowable current ratings for a bank of ChipSwitch SIP solid state relays attached to a common heatsink. Actual current ratings under various conditions of loading are given for a typical output structure.

Specification Limitations

A maximum assembly dissipation of 15 watts into a 60°C ambient was selected as a representative operating limit. Various combinations were run to determine the relay limitations under these conditions. Two cases were then run to determine the safety margins in rating the assembly at 15 watts at 60°. A limit of 120°C was placed on maximum junction temperature, allowing a large safe temperature margin for proper junction operation.

Test Set-Up

Sixteen SP6210 ChipSwitch SIP relays were mounted in a typical industry AC output module. The structure of this module can be seen in Figure 1 and 2. Thermocouples were placed in key locations throughout the system as can be seen in Figure 3.

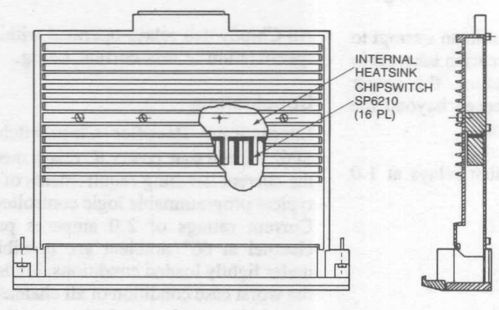

Figure 1. Typical AC output module

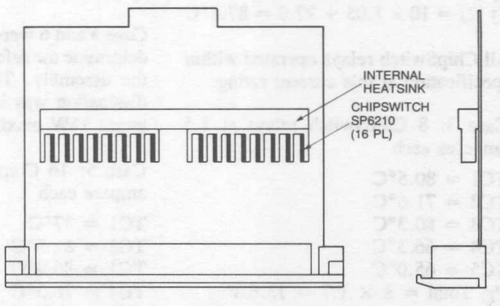

Figure 2. Heatsink configuration

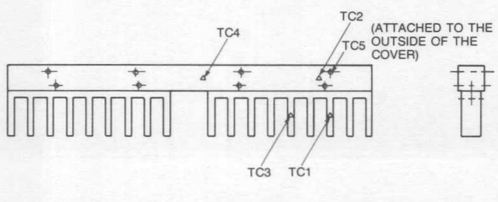

Figure 3. Location of thermocouples

Test Conditions and Parameters Employed

Ambient Temperature = 60°C $^{+2}_{-0}$ (still air)

All readings were taken after thermal stability was achieved. For the calculations in the report, the following values were employed:

— $\theta_{J\text{-}HTSK}$ = 10°C/W
— P_D — See Figure 4
All loads resistive.

Tests

Case 1: 1 ChipSwitch relay at 2.0 amperes

TC1 = 69.0°C
TC2 = 63.2°C
TC3 = 64.0°C
TC4 = 61.9°C
TC5 = 61.7°C
P_D Total = 2.56W
T_J = 10 × 2.56 + 69 = 94.6°C

The single relay operated within specification at this current rating.

Case 2: 12 ChipSwitch relays at 1.0 ampere each

TC1 = 76.9°C
TC2 = 72.9°C
TC3 = 77.0°C
TC4 = 67.2°C
TC5 = 66.8°C
P_D Total = 12 × 1.05 = 12.6W
T_J (1) = 10 × 1.05 + 76.9 = 87.4°C
T_J (2) = 10 × 1.05 + 77.0 = 87.5°C

All ChipSwitch relays operated within specification at this current rating.

Case 3: 8 ChipSwitch relays at 1.5 amperes each

TC1 = 80.5°C
TC2 = 71.6°C
TC3 = 80.3°C
TC4 = 66.3°C
TC5 = 65.0°C
P_D Total = 8 × 1.7 = 13.6W
T_J (1) = 10 × 1.7 + 80.5 = 97.5°C
T_J (2) = 10 × 1.7 + 80.3 = 97.3°C

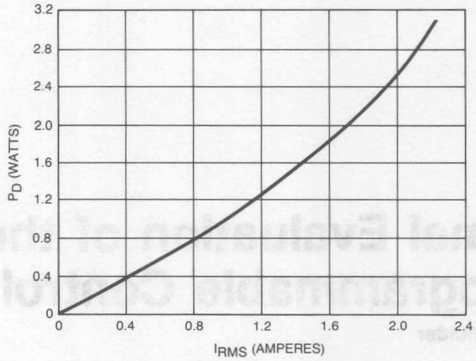

Figure 4. Power Dissipation SP6210

All ChipSwitch relays operated within specification at this current rating.

Case 4: 6 ChipSwitch relays at 2.0 amperes each

TC1 = 89.6°C
TC2 = 80.8°C
TC3 = 88.8°C
TC4 = 69.4°C
TC5 = 68.2°C
P_D Total = 6 × 2.56 = 15.36W
T_J (1) = 10 × 2.56 + 89.6 = 115.2°C
T_J (2) = 10 × 2.56 + 88.8 = 114.4°C

All ChipSwitch relays operated within specification at this current rating.

Case 5 and 6 were run in an attempt to determine the safety margin inherent in the assembly. Therefore, the power dissipation was increased beyond the target 15W maximum.

Case 5: 16 ChipSwitch relays at 1.0 ampere each

TC1 = 87°C
TC2 = 81.5°C
TC3 = 86.9°C
TC4 = 76.3°C
TC5 = 77.3°C
P_D Total = 16 × 1.05 = 16.8W
T_J (1) = 10 × 1.56 + 87.0 = 102.6°C
T_J (2) = 10 × 1.56 + 86.9 = 102.5°C

All ChipSwitch relays operated within specification at this current rating.

Case 6: 16 ChipSwitch relays at 1.5 amperes each

TC1 = 103.8°C
TC2 = 94.5°C
TC3 = 103.7°C
TC4 = 85.5°C
TC5 = 87.2°C
P_D Total = 16 × 1.7 = 27.2W
T_J (1) = 10 × 1.7 + 103.8 = 120.8°C
T_J (2) = 10 × 1.7 + 103.7 = 120.7°C

All ChipSwitch relays operated within specification at this current rating.

Conclusions

International Rectifier ChipSwitch® SP6210 solid state power IC relays meet the current handling requirements of a typical programmable logic controller. Current ratings of 2.0 amperes per channel at 60° ambient are possible under lightly loaded conditions. Under the worst case condition of all channels on simultaneously, a 1.5 ampere rating per channel can still be achieved.□

The PhotoVoltaic Relay: A New Solid State Control Device

by Bill Collins

Summary

Recent developments in semiconductor technology have led to the design of a new type of solid state relay which combines photovoltaic isolation with MOSFET power integrated circuit techniques. The International Rectifier PhotoVoltaic Relay brings solid state advantages to applications which previously could be served only by signal level electromechanical relays.

Introduction

Historically the relay is the earliest applied electrical device, preceding in relay telegraph usage the electrical motor and the incandescent lamp. The relay function of switching a load circuit with a low power, electrically isolated control circuit has been implemented by several basic design approaches. Figure 1 illustrates the relay topologies in both mechanical and solid state form which probably have been of greatest commercial significance.

The PhotoVoltaic Relay

A new topology, termed the PhotoVoltaic Relay (PVR), has recently evolved and is illustrated in Figure 2. The PVR topology achieves electro-optical isolation by means of a light emitting diode (LED) energizing a photovoltaic generator (PVG) consisting of a series connection of silicon PN junctions. The signal from the photovoltaic generator in turn activates a bidirectional MOSFET configuration.

The PVR circuit configuration achieves a unique combination of operating advantages not present in any of the topologies of Figure 1. The PVR

This application note is a reprint of a paper presented by H. William Collins at the National Association of Relay Manufacturers (NARM), April 24, 1985.

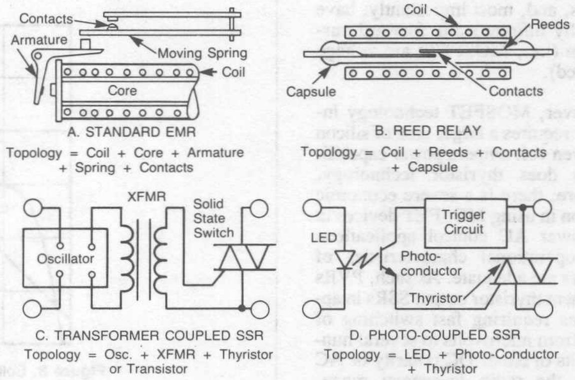

Figure 1. Common Relay Topologies

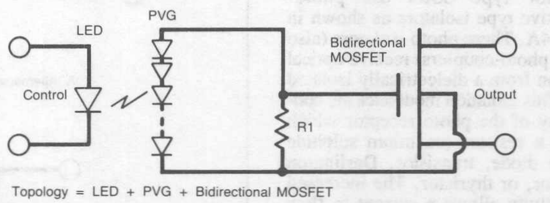

Figure 2. PhotoVoltaic Relay

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has the solid state advantages of long switching life, high operating speed, low pick-up power, bounce-free operation, non-inductive input, insensitivity to position and magnetic fields, extreme shock and vibration resistance, and miniaturization. In addition, modern MOSFET technology provides a much better analog of an ideal electromechanical switch than does thyristor or bipolar transistor technology used dominantly as the output contacts in previous solid state relays (SSRs). Relative to thyristors, the MOSFET displays a linear on-resistnace rather than an 0.6 volt threshold in forward conduction, as shown in Figure 3. An inverse series connection of two MOSFETs can switch DC or AC at frequencies well into the RF range. Static and commutating dv/dt effects are not inherent and turn off can be instantaneous. Relative to bipolar transistors, MOSFETs display lower on-state offset voltages, much lower off-state leakages, and, most importantly, have essentially infinite static forward current gain (i.e., MOSFETs are voltage controlled).

However, MOSFET technology inherently requires a larger area of silicon for a given volt-ampere power capability than does thyristor technology. Therefore, there is a severe economic limitation in using MOSFET devices in high power AC control applications where operational characteristics of thyristors are adequate. As such, PVRs supplement thyristor output SSRs in applications requiring fast switching of signals from microvolts to several hundred volts of either DC polarity or AC through the radio frequency range. These applications have commonly been served by reed capsule relays. International Rectifier's PVR now provides a functional equivalent of the reed relay and the advantages of solid state implementation.

PhotoVoltaic Isolation

Photo-isolated thyristor and bipolar transistor type SSRs use photoconductive type isolators as shown in Figure 4A. These photo-isolators (also termed photo-couplers) receive optical radiation from a dielectrically isolated LED. This radiation modulates the conductivity of the photo receptor which can be a resistor (cadmium sulphide cell), a diode, transistor, Darlington transistor, or thyristor. The increased conductivity allows a current to flow from a separate voltage source thereby producing an output signal in a load such as R_L. In a 4-terminal SSR the supply voltage can be taken from the output terminals with the advantage of eliminating a separate power source. This simplfication has the disadvantages of requiring a finite voltage drop across the terminals before turn on, increasing the off-state leakage, and providing a possible path for load transients to feed through to the sensitive input of the SSR circuitry and cause malfunction.

The isolator technique shown in Figure 4B uses a series connection of photo diodes as a photo-receptor to form an isolated photovoltaic generator. This type of isolator actually transforms energy across the isolation barrier and creates an isolated voltage source. As such, a separate power source is not required to achieve an output signal or the attendant problems of deriving the turn-on signal from the SSR load terminals are eliminated.

Although a photovoltaic isolation technique may seem like an ideal circuit solution, until recently there have been severe practical problems in using a photovoltaic isolator. An economically affordable and sufficiently compact photovoltaic generator produces only a weak output. A practical photovoltaic generator can generate several volts into an open circuit load, but only microamperes of output current.

However, the output of such a photovoltaic generator is an ideal match to the drive characteristics of a MOSFET. A modern power MOSFET requires several volts of signal for full conduction, but requries essentially zero steady state current. Only transient energy to charge the gate capacitance is required to turn on and then hold the MOSFET in conduction. A charging current of only a few microamperes can turn on a typical MOSFET in a small fraction of a millisecond — a fast response relative to electromechanical switching times.

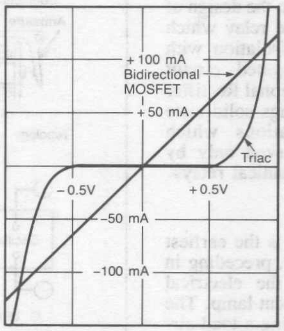
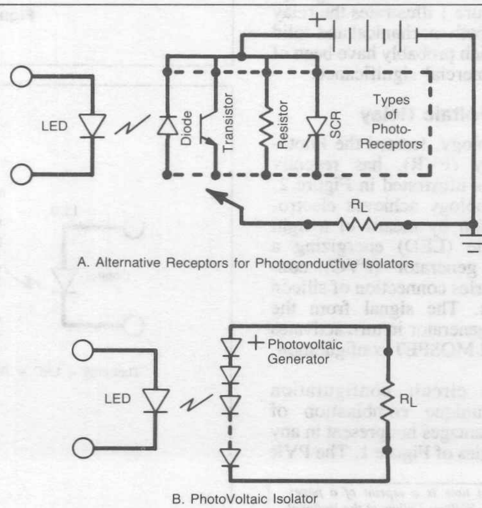


Figure 3. Solid State Output Characteristics



A. Alternative Receptors for Photoconductive Isolators

B. PhotoVoltaic Isolator

Figure 4. Types of Photo-Isolators

The PVR topology has become practical because of the perfection in the last five years of power MOSFET technology. It seems impractical to use a photovoltaic generator other than in conjunction with a MOFET gate. Thyristors and bipolar transistors both require too much drive current. Hence, the term PhotoVoltaic Relay describes not only the isolation technique but also strongly implies a circuit topology with a MOSFET output.

MOSFET Output

Figure 2 shows a bidirectional MOSFET output that can be formed by use of two N-channel MOSFETs in inverse series, common source connection. The common source connection allows control by a single photovoltaic generator. For reliable and fast turn-off to occur, this configuraiton must provide a discharge path for the gate-to-source capacitance such as provided by resistor R_1. Discharge will not occur effectively back through the photovoltaic generator because of the approximately 0.6 volt threshold conduction level per junction in the series connection of typically 10 to 20 diodes. A discharge resistor value in the 1 to 10 megohm range is desirable to prevent significant loading on the photovoltaic generator. The gate capacitance values of MOSFETs appropriate for a PVR can be in the 100 to 1000 picoFarad range, thereby producing discharge time constants in the millisecond range.

The release time of a PVR can be greatly decreased by the use of additional, active circuit elements. Circuitry using a depletion mode MOSFET normally shorted across the output MOSFET gate and turned off by a second photovoltaic generator has been previously described. An alternative method of fast gate discharge is shown in Figure 5.

Whenever the gate voltage of Q_1 is significantly more positive than the photovoltaic generator voltage, signifying that output transistor Q_1 should be turning off, enhancement mode P-channel transistor Q_2 (or a PNP bipolar) shorts the charge on the Q_1 gate to the source and accomplishes fast turn off. This circuit configuration has the advantage that only a single photovoltaic generator is required.

Using dynamic gate turn-off techniques, drop-out release times in the 10 to 50 microsecond range are easily achievable. MOSFETs switch in a bounce-free manner thereby minimizing circuit noise and eliminating settling times which can increase total switching times.

The extreme switching life possible with a MOSFET output arises because a transistor, operated at moderate temperature, does not experience any deterioration mechanism as a result of the switching action of its ''contact'' structure. The most common failure mechanism of power semiconductors results from self-heating temperature excursions from the on-off action which can cause mechanical failure of die bonds and wire bonds. Therefore, in PVR applications where on-off thermal stresses are slight, claims of near infinite switching life are justifiable.

The major weaknesses of a MOSFET output relative to metallic contacts are the closed circuit on-resistance and the open circuit capacitance. Compared to typically a closed resistance of 100 milliohms for signal level metallic contacts, a MOSFET on-resistnace can be typically several ohms. Compared to an open circuit capacitance of typically one picoFarad, a MOSFET open circuit capacitance can be typically tens of picoFarads.

Both of these parameters are under the control of the semiconductor designer within the ultimate limits of the physics of the device structure. On-resistance can be decreased by increasing silicon chip area within economic limits. The on-resistance of a MOSFET varies typically at a rate greater than the square of the design blocking voltage. Therefore, on-resistance is greatly reduced by designing the chip structure for the minimum required blocking voltage. The modern power MOSFET has resulted because of great design advances made in reducing the on-resistance for a given blocking voltage while utilizing a given silicon area. Progress in this developmental area is continuing.

Design factors which tend to decrease on-resistance (such as increased area) also tend to increase off-state capacitance. At a given blocking voltage a figure of merit corresponding the multiple of $R_{D(on)}$ times $C_{(off\text{-}state)}$ results. The ingenuity of the chip designer can minimize this number within limits, but often at the sacrifice of some other parameter such as transconductance. It follows that a full range of PVR designs will have MOSFET outputs of different blocking voltages and different chip areas thereby optimizing the interrelated on-resistance and off-state capacitance for a specific application.

Methods of PVR Implementation

The design challenge in making a practical PVR has been to implement the previously discussed concepts in a high performance, yet compact and economical manner. A discrete component approach cannot achieve either the miniaturization or cost which would allow the PVR to be directly competitive with alternative electromechanical relays. Hybrid circuit techniques, which place MOSFET and other chips on a ceramic substrate, move toward this ultimate goal. However, realization of truly competitive PVR has required innovative semiconductor processing, packaging, and advanced power integrated circuit techniques.

Both the photovoltaic generator and the bidirectional MOSFET output can be implemented by the integrated circuit technique of dielectric isolation. Dielectric isolation consists of etching grooves into a wafer of single crystal silicon, forming an insulating silicon dioxide layer over the etched wafer, and then epitaxially growing a thick layer of polysilicon to serve as the ultimate

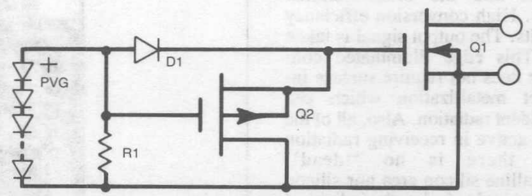


Figure 5. Gate Discharge Circuit

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physical substrate. The wafer is then inverted and the original single crystal substrate ground away until oxide insulated "tubs" are exposed. Conventional diffusion techniques can then proceed to form semiconductor components. Although dielectric isolation requries relatively little semiconductor component design innovation, it is a complex and costly wafer manufacturing process. It also places some performance limitation such as lower current conversion efficiency of the photovoltaic generator, blocking voltage problems arising from surface metallic interconnects overlaying the blocking junctions, and optically induced offset voltages in a totally monolithic chip.

Photovoltaic Generator

A high performance, compact and economical series connection of photo diodes forming a photovoltaic generator is illustrated in Figure 6.

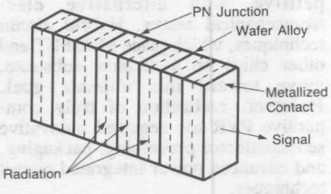

Figure 6. Edge Illuminated Photovoltaic Generator

This device is adapted from a standard manufacturing process for high voltage diode cartridges. PN junctions are diffused into individual silicon wafers. The wafers are then stacked and alloyed together. The wafer stack is then cut by a deep cut dicing saw into individual generators of the desired size. The wafer diffusion, of course, is designed for optimum photovoltaic generation rather than the requirements of a high voltage blocking diode.

This manufacturing process has great flexibility in varying both the number of diodes and the cross-sectional geometry. High conversion efficiency also results. The output signal is taken axially. This edge illuminated configuration does not require surface interconnect metallization which can block incident radiation. Also, all of the silicon is active in receiving radiation because there is no "dead" polycrystalline silicon area nor silicon dioxide required to isolate the individual PN junctions as with dielectric isolation.

Figure 7 shows the output characteristics of an edge illuminated photovoltaic isolator. This isolator utilizes a gallium aluminum arsenide LED in a reflective cavity filled with a solid dielectric and achieves over 4000 volts RMS isolation.

Power IC MOSFET Output

Development has recently been completed on a novel power integrated circuit for a PVR termed a BOSFET® (Bidirectional Output Switch Field Effect Transistor). This monolithic chip contains a bidirectional MOSFET structure, fast turn-off circuitry and supplementary gate protection. The power IC techniques of the BOSFET make a compact and economical PVR a commercial reality. Figure 8 is a photograph of the BOSFET chip.

The BOSFET uses a unique high voltage process similar to N- well CMOS. This process integrates high voltage lateral DMOS transistors with a variety of low voltage control components. The BOSFET contains n-channel and p-channel MOS transistors, high gain NPN transistors, blocking diodes, zener diodes, high valued resistors, and capacitors.

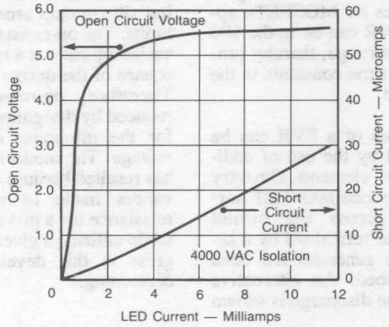

Figure 7. Output of 12 Cell Edge Illuminated PhotoVoltaic Isolator

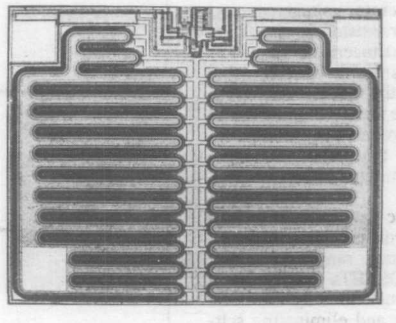

Figure 8. BOSFET Chip

The output transistors of the BOSFET use a self-aligned polysilicon gate technique to achieve the benefits of a short channel, a well controlled threshold, and a highly reliable gate-oxide interface. The process enables a single polysilicon layer to perform multiple functions. In addtion to controlling the output devices, this selectively doped polysilicon layer is used for low resistance interconnects, high value isolated resistors, voltage independent high value capacitors, and P-channel and N-channel gates. The BOSFET is derived from modern power MOSFET technology and is an excellent example of a monolithic power IC formed by conventional IC manufacturing processes.

The BOSFET chip of Figure 8 blocks ±300 volts peak and has 24 ohms maximum on-resistance at 25°C. Other voltage and on-resistance ratings can be designed by properly adapting the basic BOSFET structure. A BOSFET optimized for a PVR should combine high transconductance, low threshold voltage, low junction capacitances, and

high off-state resistance. Figure 9 shows a BOSFET transfer curve.

The variation of off-state resistance with applied voltage and temperature of a typical BOSFET is shown in Figure 10.

Operational Characteristics of a PVR

Figures 11 and 12 show a commercial PVR which is formed using a BOSFET chip and an edge illuminated photovoltaic isolator.

The PVR is a normally open, single pole configuration rated at 150 milliamperes continuous current and 300 volts peak blocking. The mechanical structure is highly adaptable to high volume semiconductor assembly processes, using transfer molding to form both the inner reflective cavity and the outer housing. Figure 13 summarizes the performance characteristics of this PVR.

The clean switching characteristics and response times of the complete PVR are shown in Figures 14 and 15.

current for turn-on, even faster actuation can be achieved by applying an initial pulse which is then reduced to a much lower quiescent holding current. Figure 16 shows an input speed-up circuit which applies a 90 milliampere overdrive pulse with approximately a 40 microsecond decay time constant, thereby achieving a 25 microsecond actuation tie. The quiescent current of 5 milliamperes which is maintained would result in a 150 microsecond actuation time without the speed-up circuit.

Release time is determined by circuit element values within the BOSFET and is largely independent of the input drive conditions.

The PVR inherently generates very low thermal voltages. This advantage arises because of the simplicity and ease of symmetry of the output structure. Even more important is the low control power generated in the package. A PVR requires only 3 milliwatts dissipation in the LED in a thermocouple switching

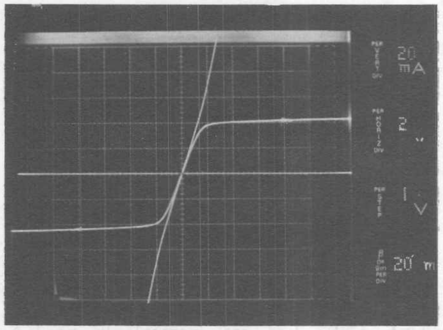

Figure 9. BOSFET Transfer Characteristics Output with 1 Volt, 2 Volt, and 3 Volt Gate Steps

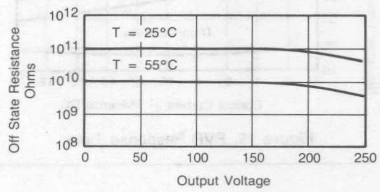

Figure 10. Typical BOSFET Off-State Resistance

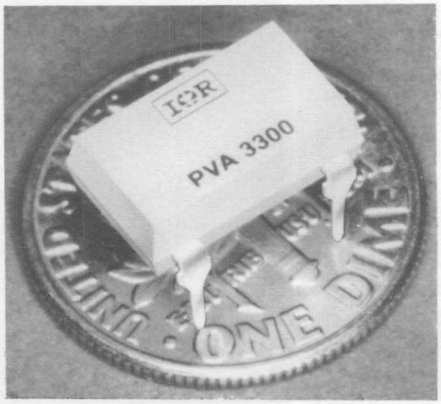

Figure 11. Photograph of Single Pole PVR

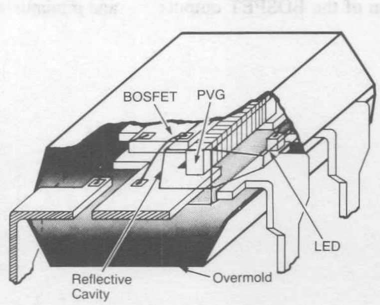

Figure 12. PVR Internal View

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Typical PVR Operating Characteristics	
Blocking Voltage:	±300V
Current Rating:	130 mA @ 40°C
On Resistance:	20 ohms @ 25°C
Off Resistance:	10^{11} ohms @ 25°C
Output Capacitance:	12 pf @ 50 VDC
Pick-up Current:	2 mA Light Load
	10 mA Full Load
Response Time:	100 µSec @ 8 mA Drive
Thermal Offset:	200 nanovolts
Pick-up Power:	2 to 20 milliwatts
Switching Operations:	10^{10} @ 20 mA
Isolation:	2500 V(RMS)
Size:	0.5 in. × 0.3 in. × 0.2 in.

Figure 13. Operating Characteristics

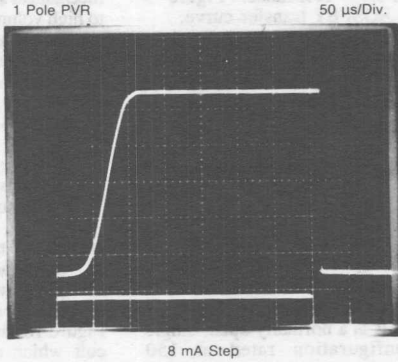

Figure 14. PVR Switching Action
Sweep = 50 µs/Div.
Signal = 8 mA Step
Upper Trace = Output Closure

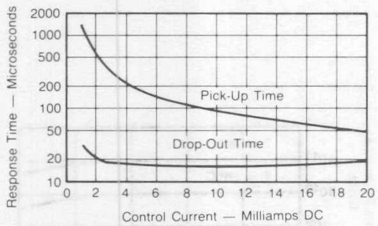

Figure 15. PVR Response Time

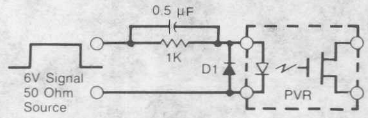

Figure 16. Fast Turn-On Circuit

application versus 50 milliwatts minimum coil power for an electromechanical relay. As a result, a PVR can readily be produced to a 200 nanovolt maximum thermal offset specification.

The output switching life of a PVR is easily demonstrated. A test was recently completed where a group of 10 PVRs were operated for 10^{10} switching cycles without failure or significant deterioration of the BOSFET outputs. The test was conducted by switching 20 milliamperes from a 50 volt DC source with 50% duty cycle at a 1 kHz rate. The 10^{10} switching operations life point is reached in about 116 days.

Conclusion

The International Rectifier PhotoVoltaic Relay can achieve previously unattainable switching life, operating speed, control power sensitivity, low thermal voltage generation, and miniaturization. These characteristics are increasingly needed by designers for process control, data acquisition, multiplexing, automatic test equipment, and telecommunications equipment. The new PVR topology will allow the venerable relay function to meet these ongoing challenges. □

Advantages of PhotoVoltaic Relays in Multiplexers

AN-105

By Allen Garfein

Introduction

While modern instrumentation system designs are almost entirely solid-state, an exception to this dominance has been the electro-mechanical relay (EMR) used in analog multiplexer inputs. Until recently, the critical performance characteristics of these switches could be met only by traditional electro-mechanical relays. There was no choice in turn to accepting the performance limitations of these EMRs.

All Solid State Multiplexers

The use of International Rectifier microelectronic power IC PhotoVoltaic Relays (PVRs) in multiplexers can greatly increase life and reliability, allow systems to operate at higher scanning rates, eliminate measurement errors from thermally generated offset voltages, reduce operating power, provide greater mechanical ruggedness, and decrease instrument board sizes. PVR devices can be widely applied in multiplexing designs as replacements for reed relays, stepper switches, crossbar switches and monolithic CMOS integrated circuits. A typical multiplexer schematic is shown in Figure 1.

Figure 2 is a pair of photographs showing a recently redesigned MUX card using International Rectifier PVRs in comparison with an older design using EMRs.

In addition to the obvious space savings, International Rectifier's PVR offers numerous electrical performance advantages. These advantages of the solid state PVR are now possible because of recent advances in MOSFET technology which allow the nearly ideal open/closed contacts of electro-mechanical switches to be essentially duplicated by semiconductor structures.

A Better MUX Switch: PVR

The numerous solid state advantages of the PVR relative to the traditional EMR allow the instrumentation designer to design more reliable equipment. In addition, by capitalizing on the unique PVR features, the innovative designer can create higher performance systems of smaller size. The major PVR advantages to MUX designers include the following:

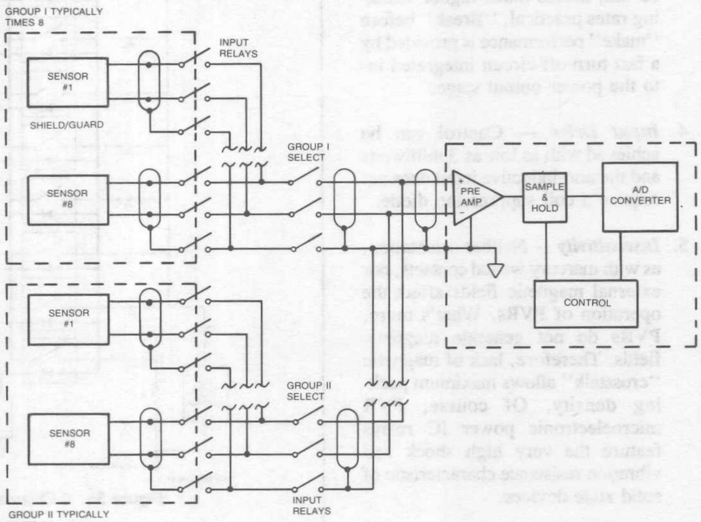

Figure 1. Typical Multiplexer System

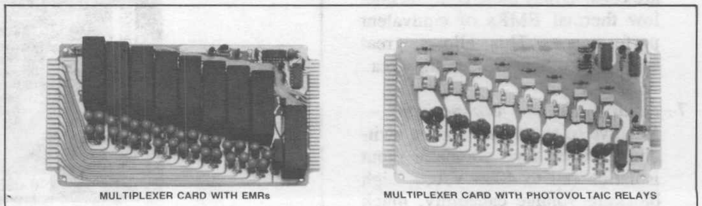

Figure 2. Comparison of Electromechanical and PhotoVoltaic MUX Board

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1. ***Life*** — PVR devices have a demonstrated switching life of 10^{10} operations (see application note AN-106) when switching signals as high as 50 volts at 20 milliamperes (1 watt). The best reed relay EMRs achieve life of only 10^9 operations at much lower power switching levels and after burn-in screening

2. ***Low-Thermal*** — PVRs easily achieve thermal offset voltages below 0.2 microvolts. This low spurious signal level is possible because the simple output structure produces minimal thermal junctions. Furthermore, the actuation power which is as low as 3 milliwatts, versus typically 50 milliwatts for a reed relay, produces negligible heating.

3. ***Speed*** — Full on-off settling times without any noise inducing bounce can be less than 50 microseconds, approximately 20 times faster than EMRs. This speed, plus the extended life, makes much higher scanning rates practical. ''Break'' before ''make'' performance is provided by a fast turn-off circuit integrated into the power output stage.

4. ***Input Drive*** — Control can be achieved with as low as 3 milliwatts and the non-inductive input does not require a coil suppression diode.

5. ***Insensitivity*** — Neither orientation, as with mercury wetted contacts, nor external magnetic fields affect the operation of PVRs. What's more, PVRs do not generate magnetic fields. Therefore, lack of magnetic ''crosstalk'' allows maximum packing density. Of course, PVR microelectronic power IC relays feature the very high shock and vibration resistance characteristic of solid state devices.

6. ***Size*** — At under 0.002 in.^{3} per pole, International Rectifier PVRs are considerably more compact than low thermal EMRs of equivalent performance. This allows great economy in board mounting area.

7. ***Analog Switch Comparison*** — Relative to solid state analog switches, PVRs have complete input isolation (up to 4000 VAC), high blocking voltage capability, much lower on-state resistance and are free of latch-up. Switches remain open when logic power is turned off. Signal sources remain separated without the precaution of disconnecting inputs or supplying short circuit protection.

Multiplexing Applications

Analog multiplexing requires an array of swtiches operating individually or in groups to connect each of several signal sources to a common amplifier or measurement system. If channels are selected in sequential order this device is sometimes referred to as a ''scanner.'' A system capable of selection in random order is usually called a multiplexer. Figure 1 is an illustration of a low level differential multiplexer using 3 switch poles per channel to connect the signal and shield or guard to the measurement system; a high gain amplifier, sample/hold and A/D converter.

Many important performance characteristics can easily be demonstrated with a simple configuration shown in Figure 3a, an 8-channel single ended multiplexer using the PVA3354 as the switching element.

DC leakage through individual switches can be observed by turning off the logic drive power and connecting a 200V supply to the MUX common. A voltmeter with 10 meg input impedance connected between an input and analog ground will show the leakage current as the voltage drop across the 10 megohm input impedance. Inversely, connecting all inputs to a 200 volt signal and measuring the output on the MUX common yields the leakage through all eight switches. Typical measurement with this method shows about 2 nA or an average off resistance of 10^{11} Ohms per channel.

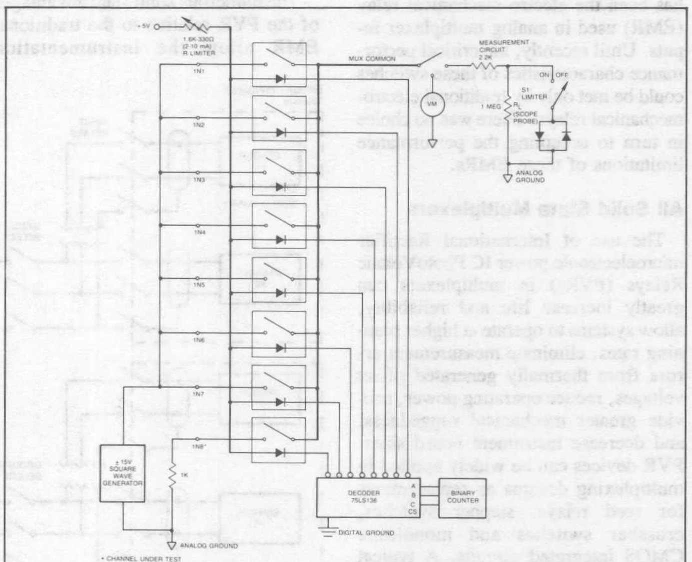


Figure 3a. 8 Channel Multiplexer Test Circuit

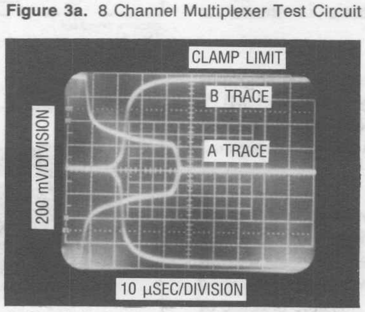


Figure 3b. Test Circuit Switching Characteristics. Test conditions use PVA3354 devices, approx. 1000 channels/sec, LED drive 5 mA, scope triggered on leading and trailing edge of drive pulse

With logic power applied, a binary counter and decoder sequentially scans all eight channels. Note that no delay is needed between successive addresses because of the "Break" before "make" operation of the PVA. The channel under test is connected to a 1K Ohm zero volt source. The seven remaining inputs are tied to the output of a 30 Vp-p square wave generator to demonstrate the effects of crosstalk and settling after extreme preconditions on the prior channel. By adjustment of the control current limiting resistor, the effect of varying control current on switching speed is apparent. The use of a square wave will also show the effects of crosstalk as a disturbance of the settled 0 voltage signal. Superimposed oscilloscope photos of the turn-on and turn-off of the channel under test are shown in Figure 3b. The pair of "A" traces display settling of the channel under test to 0 volts. The "B" traces show the turn-off with the selection of the next channel. On turn-on, a short delay occurs before the prior channel is disconnected from the MUX common. The MUX slowly drifts toward 0 until the channel under test begins to turn on and rapid settling occurs. On turn off, the short delay is experienced but the MUX common does not appear to move until the next channel begins to turn on. Note that full transition occurs in less than 50 microseconds. The traces of 3b are taken with the diode clamp circuit connected to prevent overloading the oscilloscope input.

The dependence of switching speed on control current is shown in Fig. 4. Switching speed of an order of magnitude faster than a high quality reed switch is readily obtained with a series 74LS driver. The turn-off delay remains nearly constant until the drive pulse width is too narrow to allow complete charging of the fast turn-off circuit, extending the delay before turn-off occurs. Charging may be made faster with greater control current or using an RC circuit to speed charging while limiting the steady state current to a nominal value.

The closed circuit resistance of a PVA series device is greater than that of a metallic contact. A bidirectional 300 volt relay, e.g., the PVA3354, has a typical on-resistance of 20 Ohms. A 100 volt PVA1354 offers a 5 Ohm resistance. Comparable unidirectional 300 and 100 volt blocking relays, such as the PVD3354 and PVD1354 devices, reduce on-resistance by a factor of 4:1 or 5 and 1 Ohm respectively. While the resistance is significant it is stable and does not degrade with switching, allowing for compensation in the design or calibration of the system.

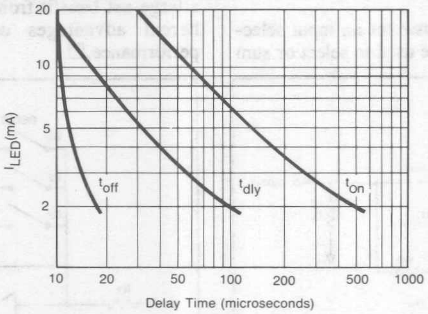


Figure 4a. Typical Delay Times

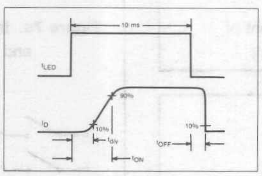


Figure 4b. Delay Time Definitions

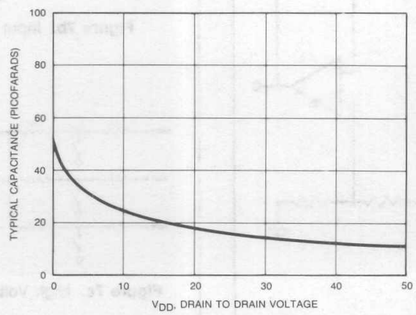


Figure 4c. Typical Output Capacitance

Multi-Level Multiplexing

The maximum voltage occurring across an open switch must be limited to less than the maximum blocking voltage or avalanche can occur. For example, if it is necessary to monitor signals on separate phases of the 120V AC line, a multi-level multiplexing scheme as shown in Figure 1 can be used to double the number of open switches between phases. This increases the maximum blocking voltage between groups to 600V.

To achieve a low on-resistance, a solid state switch requires a large area chip resulting in greater capacitance than a metallic contact and this must be considered in evaluating crosstalk for high frequency signals. Nonlinear open circuit capacitance of a PVA, shown in Figure 4c, varies from 50 to 10 pF with voltage. Larger signals or signals with DC bias reduce capacitance and result in less crosstalk.

Cascading through 2 switching levels also reduces crosstalk. For example, the worst case capacitive coupling for a 64 channel MUX is reduced by a ratio of 14/63 or −13 db over a single level multiplexer.

The "T" Switch

Certain applications may benefit from improved crosstalk rejection provided by the "T" switch illustrated in Figure 5a. By attenuating the capacitively

coupled noise signal through shorting switch, S3, a much smaller error signal can pass through to the MUX output. The "T" switch should be considered where pulse or high frequencies are to be multiplexed. The equivalent circuit shown in Figure 5b may be used to calculate the worst case cross talk for the PVA3354 device.

Flying Capacitor Multiplexer

A flying capacitor multiplexer, shown in Figure 6, utilizes two pairs of switches per channel to isolate both signal and return from the measurement system. This type of MUX is usually applied to low level, low frequency inputs, e.g., therocouples with accompanying high common mode voltages. This technique offers excellent common mode rejection and isolation of the common mode source from the measurement system. A low pass filter, R1, R2, C1, is often used on the input. The flying capacitor, C2, is initially charged to the signal voltage through S1 and S2. Using metallic contacts, rapid charge transfer between capacitors results in contact pitting as the switches make initial contact. Resistors R3 and R4 are used to limit the peak current to extend the life of the contacts. A semiconductor switch does not suffer from pitting and can easily handle the transient current on switch closure, eliminating the need for resistors R3 and R4 and their resultant scaling error. The life of the PVA relay is therefore extended many times over that of a high quality reed switch.

Variations

Figure 7a illustrates applications of a PVA series microelectronic power IC relay to an analog integrator. S1 causes a reset by shorting the feedback capacitor. S2 and S3 vary the integration time constant.

Figure 7b illustrates an input selector which can be used to select or sum inputs to an operational amplifier.

High voltage signals can be attenuated in a manner necessary for accurate selection of multiple inputs as shown in Figure 7c. The 300 volt blocking capability of the PVA3354 allows a relative high ratio of R_2 and R_1, thereby minimizing any loading or interference effects between channels.

Solid State Conversion

International Rectifier's new microelectronic power IC relays, combining MOSFET outputs with photovoltaic isolation, are replacing electro-mechanical relays in many advanced multiplexer and instrument related designs. Although there are some limitations, such as open circuit capacitance and closed circuit resistance, the knowledgeable designer can overcome these difficulties and reap a large net benefit from the many inherent advantages of solid state performance.□

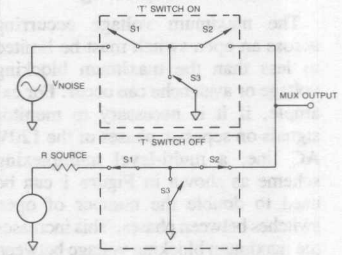


Figure 5a. Simplified Schematic of 'T' Switch MUX

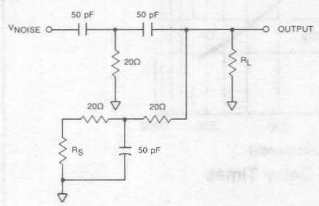


Figure 5b. Equivalent of 'T' Switch Circuit

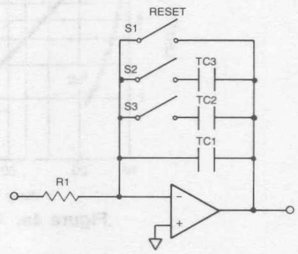


Figure 7a. Integrator Time Constant and Reset Selector

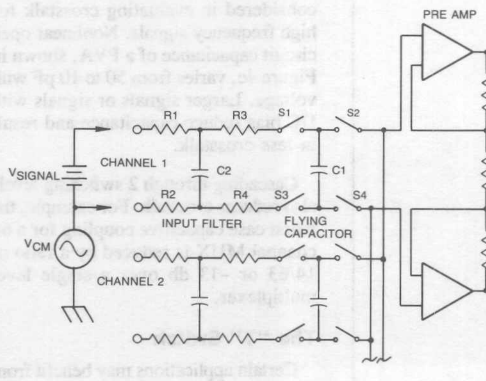


Figure 6. Flying Capacitor MUX

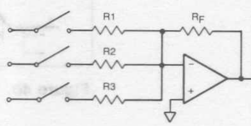


Figure 7b. Input Selector

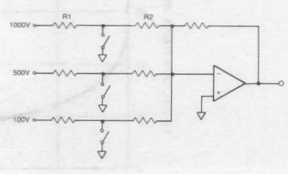


Figure 7c. High Voltage Selector

The Switching Life of BOSFET® PhotoVoltaic Relays

(BOSFET is a trademark of International Rectifier)

by Bill Collins

Introduction

All electromechanical relays have a finite switching life resulting from mechanical fatigue and contact deterioration. In contrast there is no inherent deterioration mechanism in a solid state switching device resulting from the change of state from blocking to conducting or vice versa.

The best electromechanical relays can achieve an effective life of 10^7 to 10^9 switching operations, depending on relay type and load conditions. The longest life of 10^9 switching operations is usually achieved by reed capsule relays, but only at light, non-inductive loads and after a burn-in screen. Applications such as Automatic Test Equipment and Scanning Multiplexing systems which require very long switching life can be best served by the inherent lack of a wear-out mechanism of solid state devices.

The BOSFET Power IC

International Rectifier PhotoVoltaic Relay (PVR) devices use a proprietary power integrated circuit, termed a BOSFET, to overcome many limitations of electromechanical relays. A primary advantage of the PVR is the use of the BOSFET as a solid state switch to avoid the wear-out mechanism of metallic contacts. The data reported in this application note demonstrate a minimum of 10 billion (10^{10}) switching operations with no degradation of the PVR microelectronic devices under test.

Test Technique

Relay Part No.:	PVR3301
Sample Size:	n=5 relays, 10 poles
Switching Rate:	1 kHz
Duty Cycle:	50%
Ambient Temp:	25°C
Input Current:	I_{LED} = 5 mA
Output Load:	20 mA, 500 VDC (1 watt resistive)
Failure Criteria:	All parameters to remain within published specifications

The life test setup has five two-pole International Rectifier PVR3301 PhotoVoltaic Relays per fixture and through a timing circuit switches their inputs rapidly. The output in turn switches a load current through a resistor at the same rate. The test is operated continuously.

The selected one kilohertz rate, with a 50% duty cycle was used so that approximately 10^8 operations were completed each day. Each pole was on for 500 microseconds and off for 500 microseconds for one complete period of the input timing circuit. Life test data was taken as follows: 10^8, 10^9 and 10^{10} operations (approximately 115 days continuous operation). All specified parameters were measured at each life increment.

Test Results

No PVR microelectronic switching device under test exhibited any failures or any parameteric drift out of tolerance.

Conclusion

The test results demonstrate that the switching life of International Rectifier's PVR is in excess of 10^{10} operations. Note the the 1 watt load is considerably higher than the load normally used with comparable tests of reed relays. The semiconductor component parts of all IR PhotoVoltaic Relays are identical. These include the Series PVR, Series PVA and Series PVD. Therefore, the expected life of each of these devices will be comparable to that of the life of the PVR3301 microelectronic relay reported in this application note. □

Microelectronic Relay Designer's Manual

International Rectifier

Short Circuit Withstand Capability of the Photovoltaic Relay

(BOSFET is a trademark of International Rectifier)

by Stan Schneider

Introduction

International Rectifier's power IC, the Bidirectional Output Switch Field Effect Transistor (BOSFET), is designed to insure the performance and reliability of IR's photovoltaic relay (PVR) line of microelectronic products. This monolithic chip features a bidirectional MOSFET structure capable, under many load conditions, of withstanding a direct short of its load. Self-protection and resettable fusing are consequences of this property of the PVR. The conditions under which this extremely useful characteristic can be utilized are the subject of this application note.

The PVR Design

The photovoltaic relay is constructed as shown in Figure 1. It consists of an infrared emitting LED which energizes a photovoltaic pile. In turn, this photovoltaic pile generates a voltage of sufficient magnitude to turn on a pair of BOSFET chips to which its output is connected. This pair of N-channel devices, both of which are on the same piece of silicon, may be connected in series for an AC/DC switch or in parallel for a DC-only switch. The patented BOSFET design includes a fast turnoff circuit to control its gate. This enables the unit to operate with turn-off times as low as 15 microseconds. It also insures break-before-make operation.

Withstand Capability

The short circuit withstand capability of the PVR arises from the complementary interaction of all its key elements. These include the BOSFET itself which provides an initial current limit because in the operating region it is inherently a constant current device. The BOSFET, as a typical MOSFET device, also exhibits a positive temperature coefficient of resistance. Additionally, the photovoltaic pile has a substantial negative temperature coefficient of output voltage. Finally, the emissivity of the LED also falls off with increased temperature. Therefore, as a short circuit of the load is incurred, a chain of events occurs in sequence. The transconductance limited current in the BOSFET holds the initial current maximum low enough to avoid damage. The over-current through the BOSFET raises its temperature and therefore its resistance. The increasing temperature then causes the photovoltaic pile output to fall. This fall in output reduces the gate voltage of the BOSFET and consequently drives its resistance up. This effect becomes substantial as the gate voltage drops below the BOSFET threshold voltage and the device enters a region of linear control. Finally, the LED emissivity falls causing a reduced photon input to the photovoltaic pile and a lower voltage output which results in a still higher on-state resistance for the BOSFET.

All these effects can be seen in a typical current curve under short circuit conditions. Figure 2 shows the two possible situations. In Figure 2A the PVR is turned on into a short circuit. In Figure 2B the PVR is already on and a short circuit occurs. The final result is the same in either case. The PVR limits the current to approximately 20 milliamperes in spite of being directly connected across a 60 volt line. Initially higher currents appear, as may be expected, when the load is shorted when the PVR is already on.

The short circuit properties of International Rectifier photovoltaic relays are a function of both the voltage applied to the output of the PVR and the current applied to the input. Below some characteristic voltage for any given input current the device is short circuit proof with no limiting resistance in the circuit other than some minimal source resistance. This source resistance has been reduced to as small a value as possible for the experiment. It is believed that the effect of source resistance on the characteristics developed in this application note is negligible.

Figure 3 illustrates the short circuit properties of the PVA3354 photovoltaic relay. This curve was generated by turning on the PVR into a short circuit with limiting resistance as indicated. The curve shows a typical maximum voltage that can be sustained without damage. Figures 4 through 10 illustrate the short circuit properties of other photovoltaic relay models. The curves are for typical units at the input currents specified. For guaranteed performance for all units a safety margin of 10% should be applied to the voltage values shown in the curves.

In many applications, particularly where the end user accessible terminations are standard, or where loads can readily short, this property of the BOSFET is of high importance. Chance misconnections or load failures will not damage the circuit nor will a fuse need replacement. Shortly after relieving the fault, the circuit will once again function properly.

Programmable Fuse

As a programmable resettable fuse, the photovoltaic relay can readily be adjusted to accept an operating voltage within its range by varying the input current. In Figure 11, it can be seen

that short-circuit protection for International Rectifier's PVA3354 occurs at 60V no matter what the input current. As the input current is reduced, the voltage to which the PVR is protected rises to 300V. Figure 12 gives the comparable curves for another IR device, the PVD3354. As an explanation of these curves it is clear that a reduction in input current will cause a corresponding decline in the output of the photovoltaic generator. Figure 14 shows that the current limit point decreases as the BOSFET gate voltage declines. Initial current declines accordingly, allowing higher voltages, since the limitation on the short circuit performance is the maximum energy which can be dissipated in the BOSFET. Actual overload current (fusing current) allowable before the occurrence of shutdown versus input current is shown in Figure 13. There is, of course, an input threshold value for the device to turn on at all. Above this value the allowable peak current increases rapidly with input current.

Thermal Stress

An inspection of the shorted load curves for the PVA3354 (Fig. 2A) shows that the peak current attained when the device is turned on into a load short circuit is approximately 0.9 amperes. The output curve of the device indicates that R_{DS}(on) at this point has risen to 65 ohms (typical) compared to 19 ohms (typical) at 20°C. At this point internal dissipation reaches 54 watts. The initial current is rapidly reduced due to the various thermal effects previously described, falling to 17 mA after 20 seconds. Under these conditions power dissipation is only 1 watt and R_{DD} equals 3500 ohms. This compares to 0.35 watts dissipation under normal maximum load. Clearly the steady-state stress on the BOSFET when it is in its fusing mode is relatively small.

Conclusion

International Rectifier PhotoVoltaic Relays exhibit short circuit self-protection over a wide range of performance. In addition, they can be programmed to act as an extremely fast acting resettable fuse to protect other devices. This property makes the PVR particularly useful in circuits where misadventure or end user misconnection can cause load short circuits. These certainly include, as a minimum, telecom line interfaces and PLC output modules. In these applications the need for replaceable fuses can often be eliminated and circuit damage prevented. □

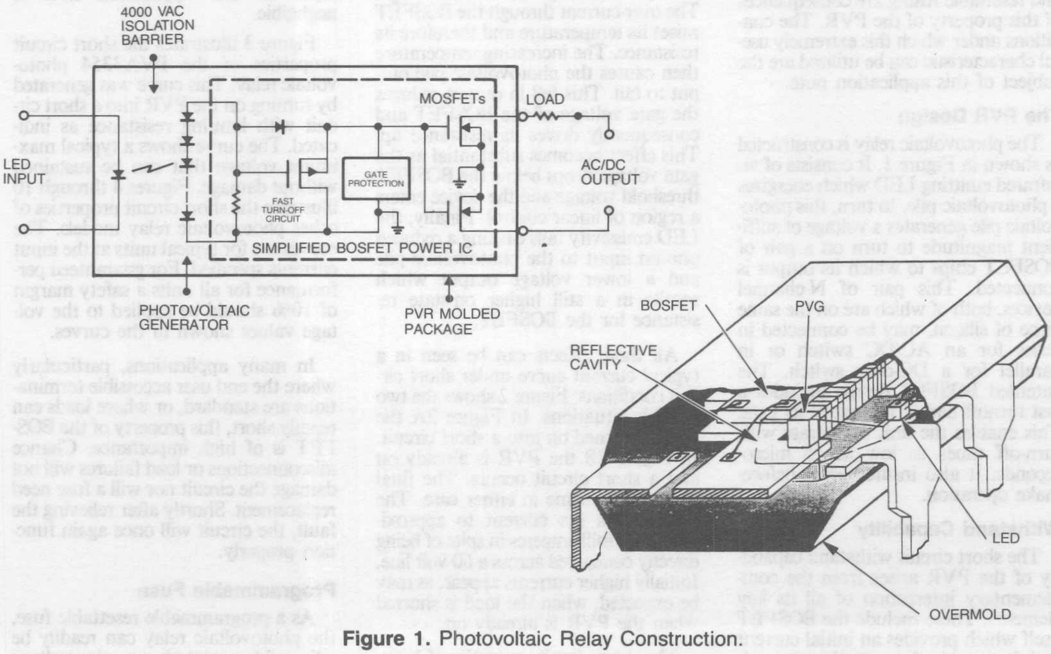
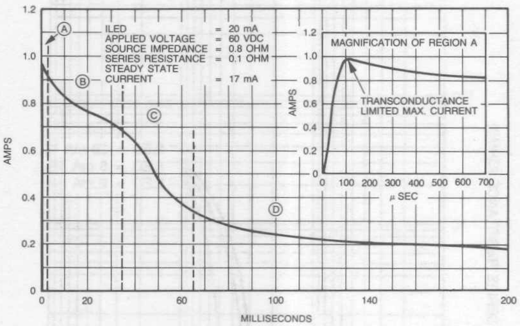
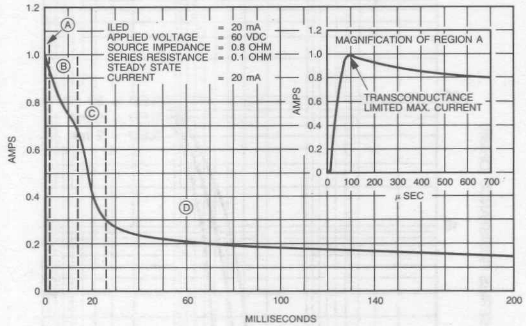


Figure 1. Photovoltaic Relay Construction.

Device Turned On Into a Shorted Load



Load Shorted With Device Already On



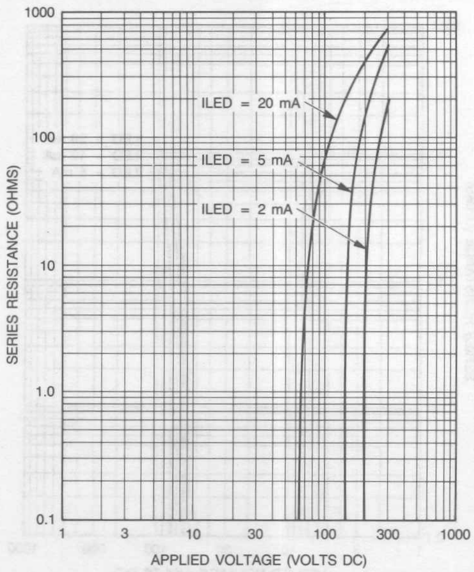
A. Region in which output current is primarily limited by transconductance.
B. Region in which BOSFET heating additionally limits output current.
C. Region in which the Photovoltaic Generator voltage approaches the BOSFET threshold.
D. Region in which LED emissivity reduction contributes to output current reduction.

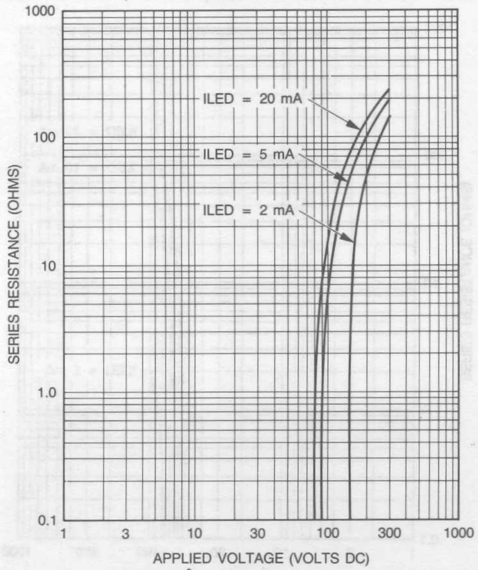
Note: Steady state current reached in 20 seconds.

Figure 2(a). PVA3354

Figure 2(b). PVA3354

Typical Series Resistance Required For Short Circuit Protection (Device Turned On Into a Load Short Circuit)





Note: Any operating point to the left of the control curve is inherently short-circuit proof.

Figure 3. PVA3354

Figure 4. PVD3354

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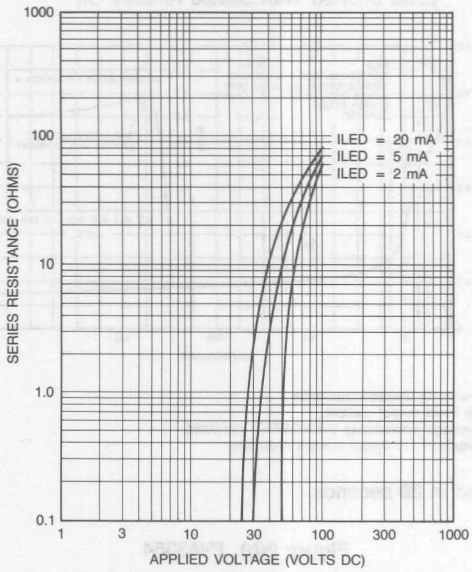
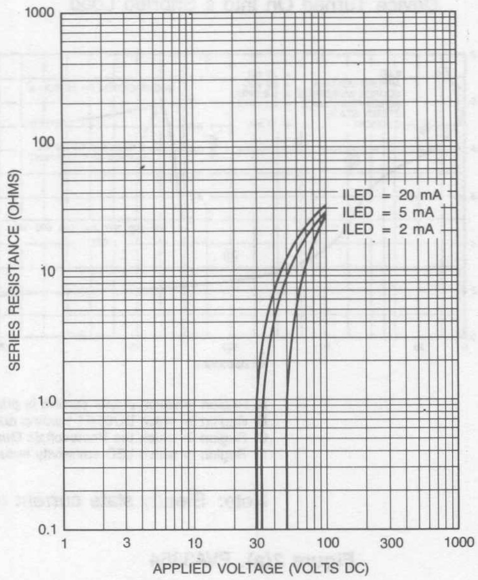
Typical Series Resistance Required For Short Circuit Protection (Device Turned On Into a Load Short Circuit)



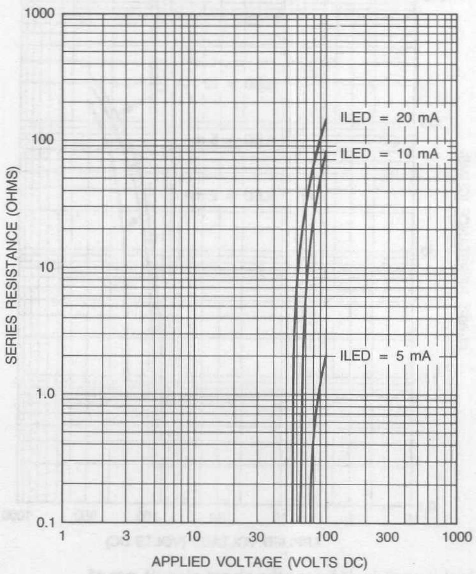


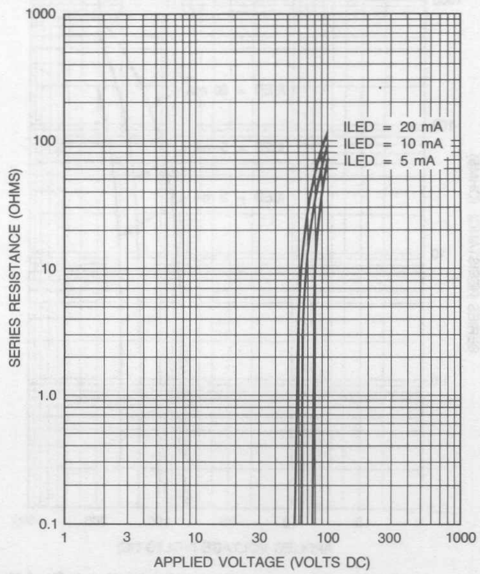
Note: Any operating point to the left of the control curve is inherently short-circuit proof.

Figure 5. PVA1354

Figure 6. PVD1354

Typical Series Resistance Required For Short Circuit Protection (Device Turned On Into a Load Short Circuit)



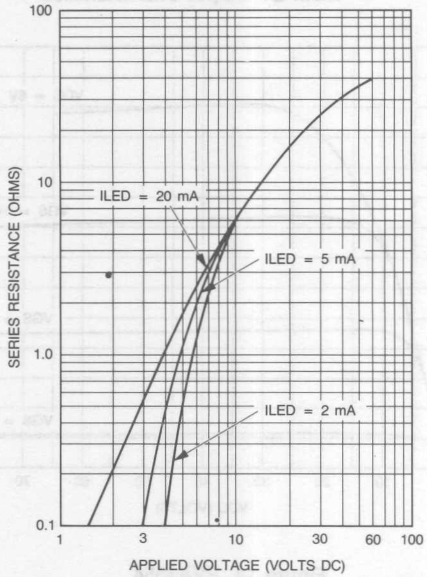


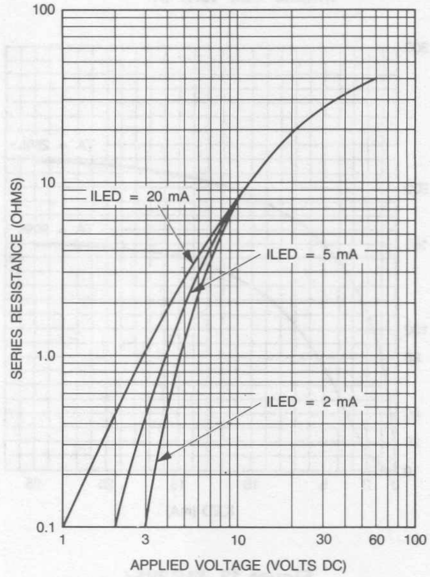
Note: Any operating point to the left of the control curve is inherently short-circuit proof.

Figure 7. PVA1054

Figure 8. PVD1054

Typical Series Resistance Required For Short Circuit Protection (Device Turned On Into a Load Short Circuit)



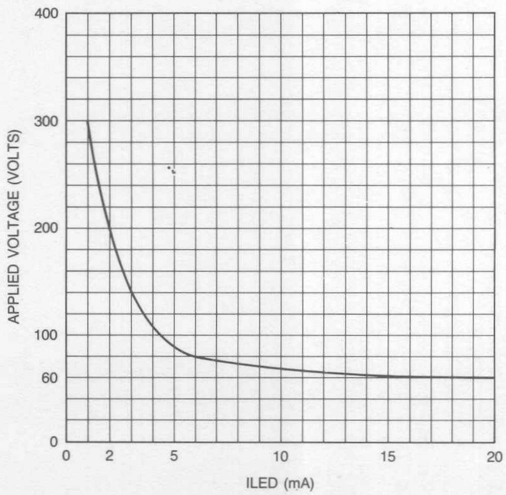


Note: Any operating point to the left of the control curve is inherently short-circuit proof.

Figure 9. PVAZ172

Figure 10. PVDZ172

No Series Resistance Required for Short Circuit Protection (Device Turned On Into a Load Short Circuit)



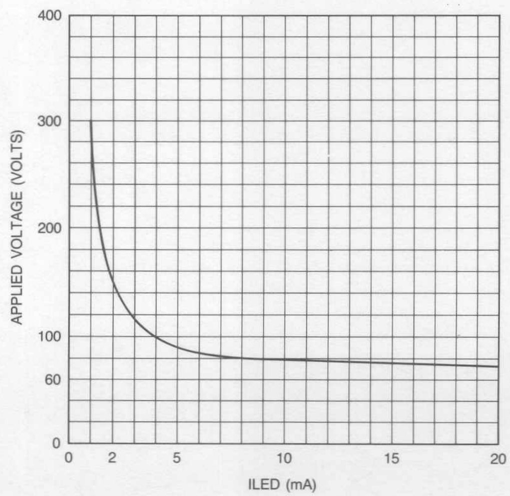


Figure 11. PVA3354

Figure 12. PVD3354

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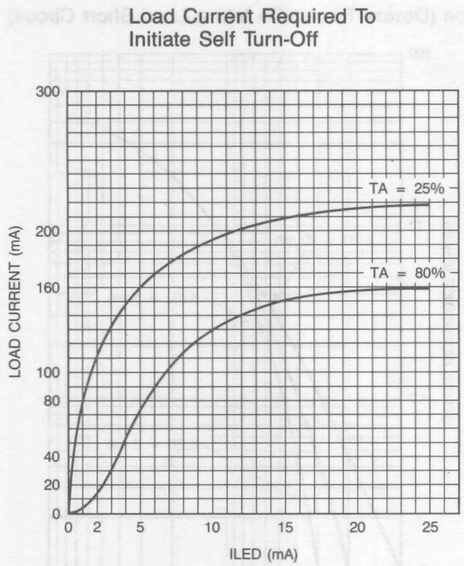


Figure 13. PVA3354

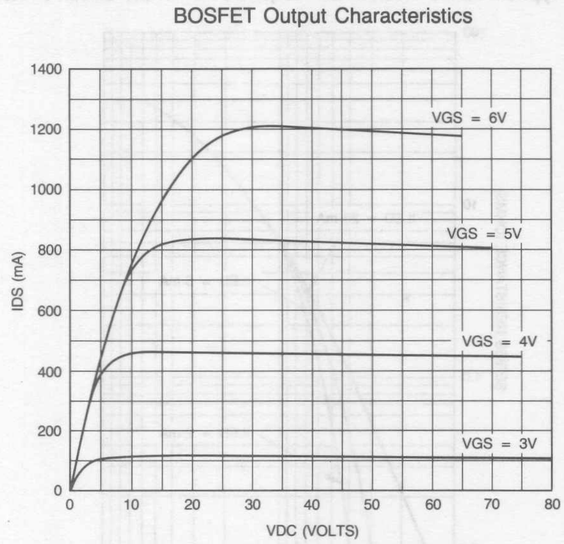


Figure 14. PVA3354

GBAN-PVI-1

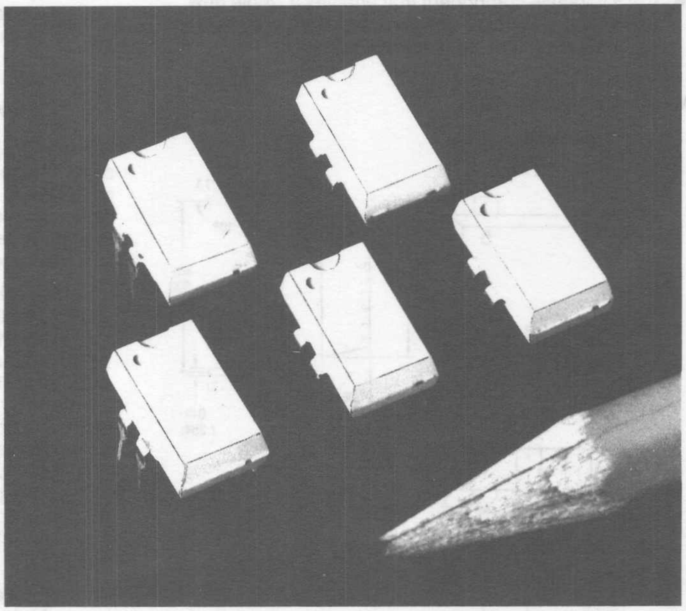
The PVI — a Versatile New Circuit Element

D. W. Moore, Technical Manager, International Rectifier Co (GB) Ltd

The PhotoVoltaic Isolator (PVI) from International Rectifier, is a revolutionary component that can simplify many existing circuits, allow the creation of new designs, and achieve miniaturisation and cost reduction.

This article will explain the internal workings of the device, discuss its characteristics and give some application examples.

From this starting point the circuit designer will soon realise the further application potential of this new technology component and turn imaginative designs into practical solutions.



The Function Basics

In the simplest terms, the PVI is an isolated 5V source powered by a LED, all in an 8-pin dual-in-line package; of course there's more to it than that, but just think for a moment how this function could be achieved with "traditional" components:

- an oscillator, transformer, rectifier solution; probably 6 or 7 components, slow to start up, radiating electrical noise and acoustic noise from the transformer, output filtering required to remove the AC content, maybe 15 or 20 solder joints, etc, certainly larger than an 8-pin DIP and also costly to assemble.
- an extra transformer winding solution; it has to be built into the transformer from the start reducing the winding window for the main power windings, it would still need rectifier and smoothing components to produce DC; but would the extra winding achieve 2500V AC isolation and how would you control the DC — probably by a photo coupler! Yet more components and complications.
- a charge pump solution; this would need a switching component, diodes and storage capacitors, but the produced voltage would not be floating nor would it be easily controlled.
- a battery solution; fine if you need a fixed floating voltage for a limited time, but how could it be recharged, and how could it be varied? Another photo coupler/transformer link is required to control the load connected to the battery.

All of these solutions are considerably more complex than using a single PVI device since it provides in one package a floating variable and controllable DC source with only four connections, all in a volume of 0.25 cubic centimetres!

F

This new technology device can be considered as a building block in any of the following types of applications:

- it is a miniature source of 5V,
- it is a floating bias supply,
- it is an optocoupler,
- it is a signal isolator,
- it is a linear current transformer,
- it is a DC to DC transformer,
- it is a Solid State Relay driver,
- it is an I/O interface,
- it is a versatile component that enables a whole new approach to circuit designs, allowing previously complex circuits to be banished forever.

Mechanical Specifications

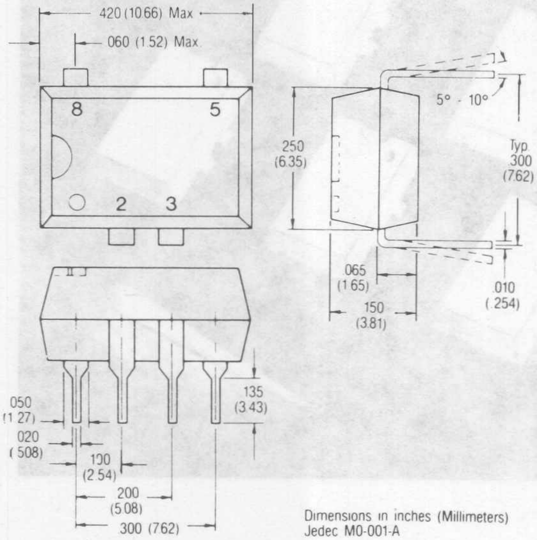
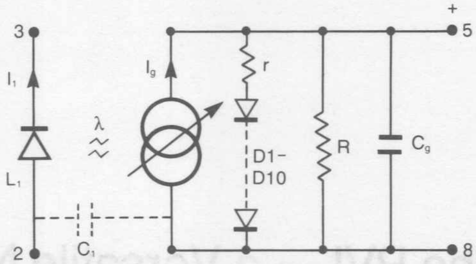


Fig. 1. Dual-in-Line Package.

How it Works

The heart of the PVI is a miniature array of alloyed silicon photo cells, 3mm long by less than 0.5mm wide, this is positioned about 1mm from a high output stability Gallium-Aluminium-Arsenide light-emitting diode and moulded within a clear plastic optical cavity to produce an efficient transfer of infra-red energy from the LED to the photovoltaic pile. This sub-assembly is then further plastic moulded to exclude ambient light, the finished package is the standard 8-pin dual in-line as shown in Fig. 1. Although the photovoltaic cells can generate around 5V, they are really quite small and have a limited current generating capability. A better understanding of the PVI's characteristics is obtained by examining the equivalent circuit shown in Fig. 2. The input current I1 is converted to infra red radiation by the LED L1. This



Typical Values for PVI5100

I_1 = 20mA	$I_g = I_1/1000$
I_g = 20 µA	C_g = 100pF
r = 30 kΩ	C_1 = 1pF at 2500V AC
R = 100MΩ	

Fig. 2. PVI Equivalent Circuit.

radiation is optically directed to the surface of the photocells to generate a current Ig which is directly proportional to the incident energy. The physical, electrical and mechanical arrangements determine the current transfer ratio at about 1000:1 (approximately linear but does have negative temperature coefficient).

Unfortunately, in any photocell, the current source is shunted by the diode-like forward characteristics of its own elements, this is represented by the series string of 10 diode junctions D1 to D10 in parallel with the current source, it is these that limit the maximum output voltage to around 6V and also introduce a negative temperature coefficient for the output voltage. These diodes have a total bulk slope resistance "r", and because of surface leakage across the photocell array and diodes as well as through the package, there is a parallel resistor "R". The coupling capacitance between L1 and the photovoltaic array is only 1pF, and the dielectric can withstand at least 2500V AC.

The photocell structure has an inherent self capacitance, this is represented by Cg and does to some extent limit the minimum switching times achievable but as we

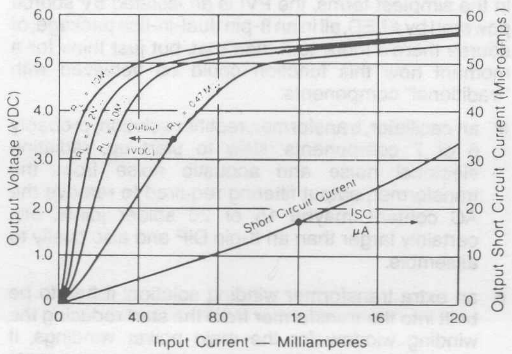


Fig. 3. PVI Output Characteristics.

shall see later, quite respectable turn-on and turn-off times of the order of 20 micro seconds can be achieved, although this does depend on the load resistance and capacitance.

Typical output characteristic are shown in Fig. 3, the short circuit current has a temperature coefficient of −0.66%/K and the maximum output voltage a −0.35%/K temperature coefficient.

To simplify the application examples, we shall show the PVI as just a variable voltage source as in Fig. 4, but remember it has a significantly high source impedance of about 500K ohm.

Applications

As this is a new type of device, there are no established or well known "traditional" applications, but once the novel features of the PVI are understood, the circuit designer will realise the simple solutions that it can offer, so to trigger the imagination here is a general discussion and some application examples.

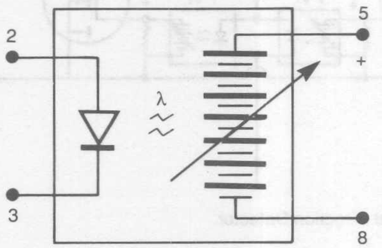


Fig. 4. Simplified PVI.

General

The output power of the PVI is about 50 micro watts, so the load has to be chosen carefully, but like any other building block they can be interconnected to give an enhanced signal, for example the nominal 5V can be increased to 10, 15, 20, 25, etc, by connecting parts in series, and the nominal 10 micro amps output current can be increased by parallel connection.

The output characteristics of the PVI are ideally suited to driving the gate of power MOSFETS, indeed it is the marriage of these two components which will produce the most popular and wide spread range of applications.

Since the gate of a MOSFET is mainly capacitance, this in conjunction with the PVI source impedance will determine the achievable switching times, for example the popular IRF620 (rated at 200V and 5A) has a gate capacitance of 600pF, and a simple calculation shows that this will be charged to 5V by 20 micro amps in 150 micro seconds, quite a respectable switch-on time. Although this turn-on action is by forcing a current into the gate capacitance, there is no such force available for the turn-off action and the charge on the gate must be allowed to leak away through the gate-source resistance. In a MOSFET this is extremely high, of the order of 2000M ohms resulting in turn-off times of several seconds, so an external discharge path must be added,

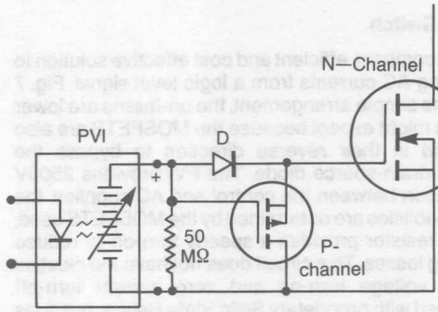


Fig. 5. Speed-up Circuit.

a typical value would be 470k ohm to bring the turn-off time down to about 500 micro seconds.

In this type of design the turn-off will always be about four times longer than the turn-on time because of the "passive" turn-off action. If there is an application where on-off times need to be more closely matched a pair of PVI devices may be used to provide a push-pull action, or the active charge dump circuit of Fig. 5 could be used. Normally the diode D is forward biased and the P-channel MOSFET is off, but when the PVI voltage drops, the diode is reverse biased, the P-channel MOSFET conducts and rapidly discharges the gate-source capacitance of the main N-channel MOSFET. With this circuit, the turn-off times can be considerable faster than the turn-on times.

A Highside Switch

To efficiently drive a MOSFET in the positive rail of a power supply it needs a gate voltage higher than that positive rail, the PVI can provide the additional voltage and at the same time isolate the control current to allow a more versatile signal source, the circuit is shown in Fig. 6. The PVI generates a floating voltage which is applied between gate and source, the resistor is to speed-up the turn-off time. The much lower on resistance of the fully enhanced MOSFET considerably reduces the losses.

The control signal and the load circuit do not need a common connection, they can be separated by up to 2500V AC, making this configuration useable as a general purpose DC Solid State Relay.

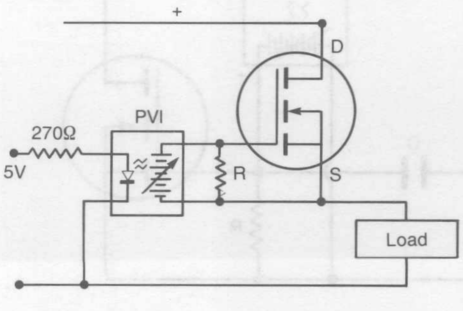


Fig. 6. High Side Switch.

The AC Switch

This is a compact, efficient and cost effective solution to controlling AC currents from a logic level signal. Fig. 7 shows the simple arrangement, the on-losses are lower than you might expect because the MOSFETS are also enhanced in their reverse direction to bypass the inherent drain-source diode. The PVI provides 2500V AC isolation between the control and AC supplies, the load capabilities are determined by the MOSFETS used, and the resistor provides a speedy turn-off to reduce switching losses. This circuit does not have the niceties of zero voltage turn-on and zero current turn-off associated with proprietary Solid State Relays, but does have the advantage of simplicity and ease to be matched to the application requirements.

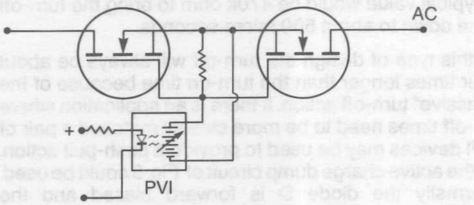


Fig. 7. An AC Switch.

The Low Power Latch

The sensitive voltage controlled attributes of a MOSFET and the characteristics of a PVI can be combined to produce a voltage triggered device with the latching characteristics of a thyristors as shown in Fig. 8. The trigger source momentarily makes the transistor conduct, the resultant current through the LED (50mA max) activates the PVI output which takes over supplying the gate and maintains the MOSFET on. To switch the device off, either the main drain current can be reduced to zero (for about 100 micro seconds whilst the gate charge is dissipated) or a negative pulse can be applied to the gate in the same manner as a Gate-Turn-off-Thyristor.

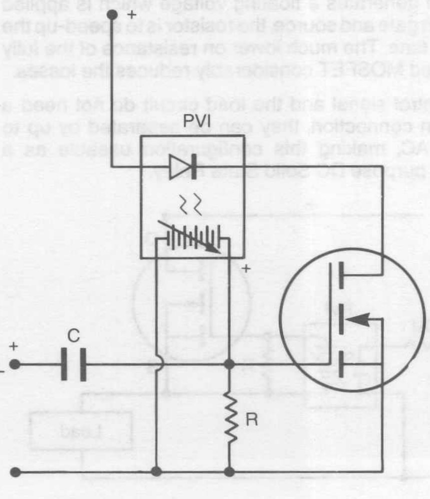


Fig. 8. A Sensitive Latch/GTO.

A Current Direction Detector

Fig. 9 shows a circuit that can control two separate loads depending on the direction of current flow in the path being monitored, the operation of the circuit is self explanatory but notice that the LED arrangement means that the "OR" function is built-in to the design, i.e. only one load can be activated at any one time.

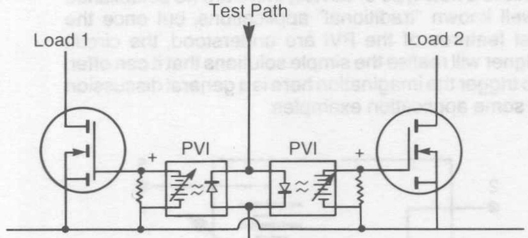


Fig. 9. Current Direction Detector.

A Miniature AC to DC Power Supply

To float charge small batteries, to power LCD displays and smoke detectors, or feed an AC derived signal to a microprocessor a very compact isolated 5 or 10V DC supply can be produced from an AC line. Fig. 10 shows the circuit arrangement with the two 5V sources in series, but they could also be in parallel to give a higher

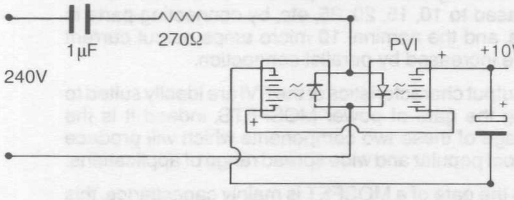


Fig. 10. An AC/DC Power Supply.

current. Because of the input current-to-output voltage characteristic of the PVI, the output has a built-in inherent voltage regulation, the output changing by less than 10% when the AC supply goes from 240V to 24V, this useful feature increases the range of application for a single functional building block in I/O systems.

A Bridge Driver

A perpetual problem with the bridge circuit used to reverse the direction of a DC motor or control an AC motor, has been coupling the control signals to the

switching elements connected to the positive supply rail. If a combination of N-channel and P-channel MOSFETS are used, then signals referenced to the positive and negative rails are required, this can deteriorate the noise immunity and make start up and signal processing difficult. By using P-channel MOSFETS the design voltages must be kept low as P-channel devices are not available over 200V.

An alternative configuration is to use all N-channel (higher voltages available) but this introduces another complexity, the gate drive signals are referenced to the sources and these follow the output voltage supplied to the load, so for a single phase drive, two floating DC supplies are needed with isolated signal coupling (photo couplers) to the control signals, and the complexities start to accumulate.

International Rectifier manufactures an integrated circuit (the IR2110) which goes a long way to solving many of these bridge driving problems but still has certain limitations, for example it is limited to under 500V DC rail application, it needs continual refresh of the high side floating supply which it derives from the output semi-conductor switches using a bootstrap technique, thus is not appropriate for steady state directional control of a DC motor.

The PVI offers a simple solution to low frequency bridge driver requirements, it is its own floating bias supply, it is isolated to 2500V AC, it can be driven from a single 5V supply, etc. The circuit is shown in Fig. 11, the signals for each LED can be connected in various configurations to suit the control signals available, an even simpler design can omit the bottom two PVI devices and the gates driven directly from the control signals. To prevent simultaneous conduction of the power devices in one arm (fire through) it may be necessary to speed up the turn-off action of each device by incorporating the circuit of Fig. 5 into each of the four PVI's.

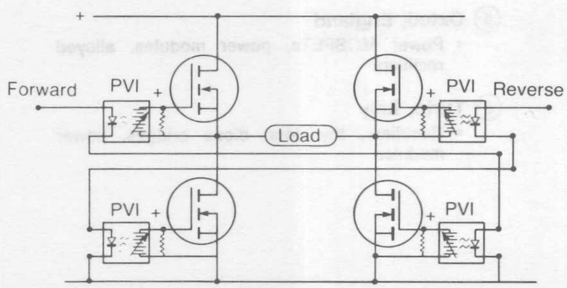


Fig. 11. Bridge Driver Circuit.

The same general arrangement of PVI-MOSFET can be used for 3 phase and 4 phase drives, used typically for inverters and stepper motors.

Conclusion

The PVI5100 is designed to match the gate characteristics of logic level MOSFETs as illustrated in this article. The PVI1050 unit is also available (see page E-1) which has a dual 5 volt output. These outputs can be series

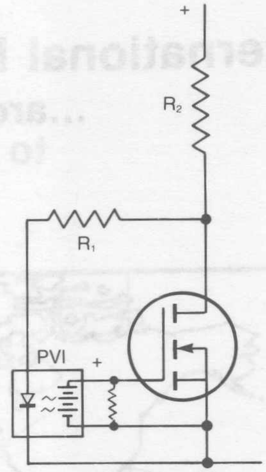


Fig. 12. What is the Action of this Circuit?

connected to drive the gates of standard power MOSFET This single 8-pin DIP PVI1050 can also be used with logi level MOSFETs in applications requiring dual outputs suc as Figure 11.

The applications for the PVI are varied yet simple and are spread across the whole spectrum of electronic/ electrical design as these examples demonstrate, and to start you thinking, what is the behaviour of Fig. 12? Could you use the PVI in an audio amplifier to simplify the design? Or could an ultra efficient synchronous rectifier circuit be designed using PVI's?

Further designs and circuits incorporating the new technology/new function PVI, are limited only by your imagination to achieve innovative, efficient and economical solutions to those troublesome circuit problems — and we are always interested in feedback from our customers, so if you are proud of your application please phone us or write with the details.

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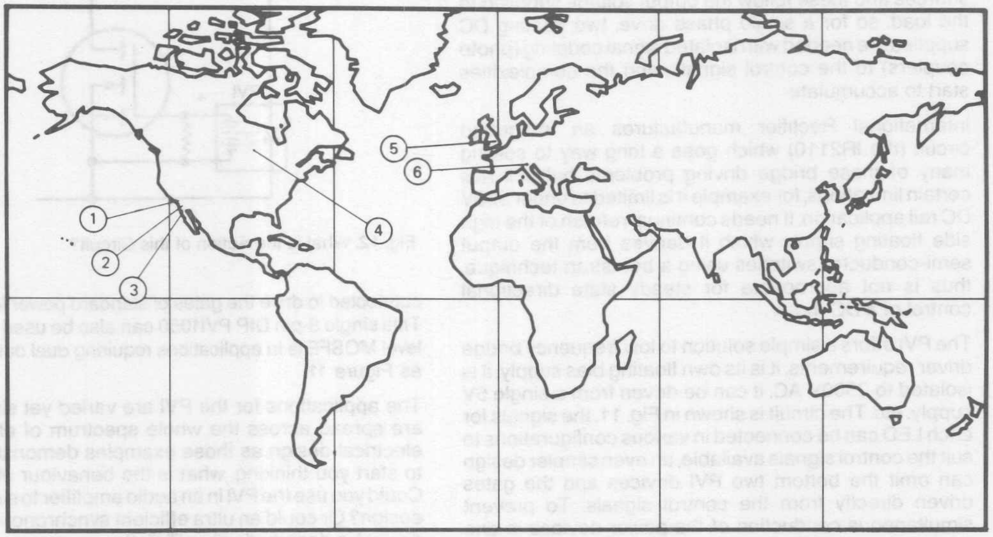

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